DEVELOPMENT OF A NOVEL FIELD-BASED LOWER-LIMB NEUROMUSCULAR SCREENING TOOL FOR USE BY TECHNICAL COACHES WITHIN FEMALE GRASSROOTS YOUTH FOOTBALL

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Abstract

Female football is a fast-growing global sport. Female players are at higher risk of certain injuries compared to males, yet research predominantly focuses on the male game. Dysfunctional movement patterns during adolescence are a key injury mechanism in female footballers. Neuromuscular screening tools (NSTs) have been used to identify high-risk young female players, but there is no consensus on the best screen for adolescent female footballers. Additionally, little research explores whether volunteer grassroots coaches without sport science support can effectively use NSTs.

This thesis documents a pilot study exploring the feasibility and initial outcomes of a novel field-based NST and continued professional development (CPD) session tailored for volunteer grassroots coaches of female adolescent footballers, evaluated using the RE-AIM framework. An initial online survey was conducted with grassroots coaches (n=111), followed by in-depth interviews with coaches of female adolescent footballers (n=8). A co-production focus group (n=2) refined the NST based on coaches' input.

The resultant hybrid NST combined an online session (oNST) and an in-person session (inNST). The oNST included demonstrative videos with ongoing assessment via closed and open-ended questions. The oNST significantly improved self-reported knowledge and confidence, with participants (n=36) answering most questions correctly. However, there were no volunteers for the inNST, preventing full evaluation of the hybrid CPD session.

The thesis concluded that while the oNST effectively improved knowledge, confidence, and perceptions, the CPD session's overall reach could be improved. The lack of inNST participation raises questions about the effectiveness of a hybrid approach. Future research should build on the inNST structure to create synchronous online sessions, integrated with the effective oNST. This blended approach could foster a Community of Practice to investigate the longitudinal impact of NST CPD sessions on volunteer coaches of female adolescent footballers. This research is a novel effort to address the real-world need for an NST CPD session tailored for volunteer coaches of grassroots female footballers.

Author's deceleration

I declare that the work in this thesis was carried out in accordance with the regulations of the University of Gloucestershire and is original except where indicated by specific reference in the text. No part of the thesis has been submitted as part of any other academic award. The thesis has not been presented to any other education institution in the United Kingdom or overseas.

Any views expressed in the thesis are those of the author and in no way represent those of the University.

Signed …  ….. Date ……26th January 2025…….

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List of abbreviations

AAA - Athletic Ability Assessment

ACL - anterior cruciate ligament

AMC - athletic movement competency

APHV – age of peak height velocity

AR – The anterior reach (AR) portion of the mSEBT

BMI – Body mass index

CoP - Communities of Practice

CPD - Continued Professional Development

DJST - Drop Jump Screening Test

EVT - Expectancy-Value Theory

FA - Football Association

FIFA - International Federation of Association Football

HHD - Handheld dynamometry

ICC - Intraclass correlation coefficient

ILL - in-line Lunge

inNST – In-person Neuromuscular Screening Tool

IPEPs - Injury Prevention Exercise Programmes

LESS - Landing Error Scoring System

LESS-RT - Landing Error Scoring System Real Time

LSI - Limb Symmetry Index

mTJA - Modified Tuck Jump Assessment

NGB - National Governing Bodies

NHL - Nordic Hamstring Lower

NST – Neuromuscular Screening Tool

oNST – Online Neuromuscular Screening Tool

PHV - Peak Height Velocity

RTBS - Resistance Training Skills Battery

RTBSc - Resistance Training Skills Battery for children

SEBT - Star Excursion Balance Test

SIMS - Soccer Injury Movement Screen

SLBT - Single Leg Bridge Test

SLCMJ - Single Leg Countermovement Jump

SLDL - Single-Leg Deadlift

SLHD - Single Leg Hop for Distance

TJA - Tuck Jump Assessment

UEFA - Union of European Football Associations

UKCC - United Kingdom Coaching Certificate

YBT - Y Balance Test

Chapter 1: Introduction

Female football participation has seen a remarkable rise in popularity, both in England and globally, across all levels of the game - from grassroots and academy football to the professional stage (The Football Association, n.d.). In 2013, it was estimated that over 29 million women and girls were actively participating in football worldwide (Martínez-Lagunas et al., 2014). This trend has been reflected in England, where figures from the Football Association (FA) indicate that there were 2.5 million registered female players in 2015, growing to 3.4 million by 2020 (The Football Association, n.d.). These statistics, however, represent only part of the story. Many girls and women participate in football informally, whether through non-affiliated clubs, schools, or recreational settings. For instance, 63% of schools in England now offer girls equal access to football during PE lessons, which has contributed to increased regular participation (The Football Association, 2021a).

The Active Lives Children and Young People Survey for 2021–2022, conducted by Sport England, highlights the growing appeal of football among girls. A third of female respondents reported participating regularly in football-related activities, with the highest rates of engagement observed between the ages of eight and 12 (Sport England, 2022). These findings underline the importance of fostering pathways for young female players to engage with the sport at various levels, ensuring that the foundations for lifelong participation are solidly established.

With increased female participation, the potential for injuries among female players may also rise (Le Gall et al., 2008). Existing studies indicate a higher injury risk for female footballers, in the range of 2.2 to 24 injuries per 1,000 hours depending on the study and methodology, compared to

1.2-6.8 injuries per 1000 hours in males (Le Gall et al., 2008; Froholdt et al., 2009). Reporting methods (player vs. parent/coach) and the inclusion of non-time-loss injuries significantly impact these rates. For instance, Clausen et al. (2014) reported higher incidence rates due to broader injury definitions.

Most football injuries occur in the lower extremities, particularly the knees and ankles (Faude et al., 2013). Common injuries include ligament sprains, muscle strains, and contusions, with adolescent females experiencing more ligament sprains (Faude et al., 2013). Severe injuries, such as anterior cruciate ligament (ACL) tears, are rare but receive disproportionate attention due to their serious implications (Fox et al., 2017). This is especially important for female players who are four to six times more likely to sustain ACL injuries compared to their male counterparts (Davidson & McLean, 2016). Although studies highlight the importance of specifying injury locations (e.g., muscle or ligament affected), the lack of medical expertise at the youth level hampers detailed reporting.

During the maturational development stage, injury patterns between male and female participants diverge, with females facing distinct risks. While various injury types are observed, the literature disproportionately emphasises ACL injuries, potentially because although ACL injuries are less common than other lower-limb sprains or strains, their impact on a participant's quality of life is profound (Fox et al., 2017). Factors contributing to this increased risk include muscular imbalances, delayed neuromuscular development, recruitment issues, changes in body shape and size, as well as hormonal and endocrine changes (Alentorn-Geli et al., 2009; Myer et al., 2008). Conversely, other often purported mechanisms of ACL injury, such as reduced flexibility or the Q-Angle has not been widely supported in literature (Thacker et al., 2004; Söderman et al., 2001) with other mechanisms, such as the size of the femoral intercondylar notch requiring further

research (Davidson & McLean, 2016). These variables are critical to consider; however, it is unlikely that a single factor is solely responsible for injury events. Instead, injuries typically result from a combination of biomechanical, anatomical, anthropometric, hormonal, and neuromuscular influences (Hägglund & Waldén, 2015; Quatman et al., 2006).

With more females than ever, who are at a heightened risk of injury, playing football, it could be argued that there is a real-world need to attempt to reduce injury risk for this population whilst also attempting to improve athletic movement competency (AMC). Neuromuscular Screening Tools (NSTs) have been suggested as a tool to identify performers at a higher risk of injury, allowing for targeted exercise interventions to be employed to reduce this risk / improve AMC of the lower limbs. A variety of whole-body screens have been developed and studied in literature, such as the Athletic Ability Assessment (AAA; McKeown et al., 2014), Resistance Training Skills Battery (RTSB; Lubans et al., 2014) and the popular Functional Movement Screen™ (FMS; Cook et al., 2014). Yet there are limitations with their use within the grassroots game, stemming from issues such as the scoring mechanism, equipment requirements, and its use for assessing dynamic movement patterns (Chimera & Warren, 2016; Fort-Vanmeerhaeghe et al., 2017). For instance, the AAA has not been applied to football players, particularly adolescent female athletes. Additionally, its implementation requires post-session analysis by the assessor (Rogers et al., 2019), further extending the time commitment for volunteer coaches, who often have limited availability. Similarly, the RTSB has limited research supporting its validity for use with children, and the child-specific RTSB lacks confirmed reliability. The FMS, on the other hand, has been criticised for its poor ecological validity in the context of football, as it does not accurately represent the complex, dynamic athletic movements required in the sport (Rogers et al., 2019). The FMS' reduced sensitivity and inability to effectively distinguish between high and low-quality movement in

adolescent athletes diminish its value as both a screening and training prescription tool (Schneiders et al., 2011).

Significant research has investigated the mechanism of injury for footballers of all ages and genders (see Chapter 2), with NSTs being developed and used to individually assess a variety of these mechanisms of injury, being categorised into; quadriceps dominance, leg dominance, ligament dominance and dynamic stability (Read, 2016). However, there is conjecture in research as to the appropriateness of these NSTs for use by grassroots coaches of female adolescent footballers. For example, research highlights quadriceps dominance, identified by reduced knee flexion during landing, as a potential ACL injury mechanism, especially in young females (Hewett et al., 2010). Handheld dynamometry (HHD) offers a portable and cost-effective alternative to isokinetic dynamometry for assessing hamstring strength, though its reliability is debated due to methodological inconsistencies (Stark et al., 2011; Thorborg et al., 2012). Nevertheless, HHD is suitable for grassroots football, particularly for adolescent females, as their quadriceps exert less force (Reurink et al., 2016). Field-based tests, like the Nordic Hamstring Lower (NHL) and Single Leg Bridge Test (SLBT), also provide practical options. The NHL, reliable for eccentric hamstring torque assessment, does not fully replicate high-speed running mechanics, limiting its application (Sconce et al., 2015; Miralles-Iborra et al., 2023). The SLBT, designed to assess strength endurance under fatigue, aligns better with football-specific demands (Freckleton et al., 2014). It has good reproducibility and identifies strength asymmetries linked to injury risk (Mahnic et al., 2021). Both screens are cost-effective and easy to administer, making them suitable for assessing hamstring strength and injury risk in youth footballers (Sconce et al., 2015; Freckleton et al., 2014).

Asymmetry between the left and right leg ('leg dominance') is more pronounced in females and correlates with increased injury risk and reduced performance (DiCesare et al., 2019; Bishop et al.,

2021). Screens such as the Single Leg Hop for Distance (SLHD) are popular for assessing asymmetry due to their ease of use and ecological validity (Hegedus et al., 2015). However, despite evidence supporting the SLHD's ability to monitor rehabilitation and identify injury risks (Read et al., 2018; McCunn et al., 2018), inconsistencies in methodology and limited adolescent research may reduce its reliability for female participants (Fältström et al., 2021; Paterno et al., 2017).

Ligament dominance, defined as valgus knee collapse upon impact, is more pronounced in females due to insufficient muscle absorption of ground reaction forces, increasing ligament strain and injury risk (Hewett et al., 2010). Tools like the Landing Error Scoring System (LESS), Drop Jump Screening Test (DJST), and Tuck Jump Assessment (TJA) are utilised to assess injury risks, though their reliability and ecological validity vary. The LESS, validated for identifying injury risks, has been reported to show high reliability with experienced raters and some novice raters. However, its real-time version (LESS-RT) may lack validation for novice raters (Padua et al., 2009; 2011). The DJST, developed for youth athletes, has also been shown to have strong reliability but limited ecological validity for football due to its passive starting position and exclusion of horizontal movements (Nilstad et al., 2014; Barber-Westin et al., 2005). The TJA evaluates lower limb landing kinematics under fatigue. Despite potential ecological validity, its reliability is inconsistent due to complexity and scoring variability. Equipment and time constraints also challenge grassroots application, though simplified versions show promise (Chimera & Warren, 2016; Fort-Vanmeerhaeghe et al., 2017).

Finally, in terms of dynamic stability, the Star Excursion Balance Test (SEBT) and Y Balance Tests (YBT) are reliable assessments used to evaluate dynamic balance, strength, and coordination (Ko et al., 2020; Philp et al., 2020). These tests require participants to engage multiple sensory systems, including visual, vestibular, and somatosensory. Both tests measure reach distances in various

directions, with the SEBT involving eight reach directions and the YBT focusing on three. Research indicates that the YBT may provide higher interrater reliability due to its specialised instrumentation, though it generally yields higher scores than the SEBT. Studies have shown that these assessments can identify injury risks, especially in athletes, with specific cut-offs for limb-length ratios linked to higher injury likelihoods. However, using these tests for individuals with previous injuries may pose challenges, as those with ankle injuries tend to perform worse (Leeder et al., 2016; Ko et al., 2020).

Overall, there is limited consensus within the industry regarding the most appropriate screening tools for grassroots coaches to use in assessing AMC and identifying potential injury risks among adolescent female footballers. Given the lack of existing tools designed specifically for field-based use by coaches in this demographic, this study was conceived as a pilot investigation to evaluate the practicality and potential value of such a tool including the accompanying training session.

1.1 Aims and objectives

Females may have increased susceptibility to injury through reduced neuromuscular control during adolescence (Hewett et al., 2016). Assessing a participant's neuromuscular abilities is crucial for identifying potential injury risks and prescribing corrective exercises to mitigate those risks. Even when the risk is deemed low, such assessments can play a vital role in enhancing AMC. Whilst there has been significant research on the development of NSTs, assessing neuromuscular dysfunction in 'real-world' practice is uncertain due to a variety of obstacles, including time constraints, lack of knowledge and education in the use of NSTs by assessors, limited equipment or funding, and a perceived lack of need (Chimera & Warren, 2016; Myer et al., 2010; Onate et al.,

2012). This absence in the literature may indicate limited awareness of NSTs among grassroots coaches of young female footballers. Indeed, most of the research in similar fields, such as injury prevention exercise programmes (IPEPs), highlights significant barriers to their use and implementation in the volunteer-led game. These barriers commonly include a lack of awareness, knowledge, time and accessibility (Donaldson et al., 2018; De Ste Croix et al., 2020; O'Brien & Finch, 2016).

The implications for long-term neuromuscular dysfunction include (a) reduced performance due to poor AMC, (b) increased susceptibility to injury, resulting in reduction/cessation of sport and physical activity, potentially leading to chronic health and wellbeing complications. Whilst there is significant positive health-benefits from participation in grassroots football, there is also inherent risk. Any mechanism that may help to reduce injury risk in football would therefore further tip the balance of improved health vs. risk to health from sporting participation. The research contained within this thesis may be another step towards addressing this disparity. This research aims to develop a novel education tool introducing NSTs in female grassroots youth football, for use by technical coaches. Increased NST knowledge would allow coaches to highlight players who demonstrate lower-limb neuromuscular dysfunction, enabling more tailored recommendations of corrective exercise protocols.

1.1.1 Aims

1. Investigate the current knowledge, confidence, perceived barriers and facilitators of youth grassroots football coaches regarding the use of NSTs
2. Develop an evidence-led NST for use within the female youth grassroots game

3. Design and pilot an evidence-led and industry-aligned coach education session outlining a NST for use within the female youth grassroots game
4. Provide recommendations for future developments in the field of coach education related to NSTs in the female youth grassroots game.

1.1.2 Objectives

1. Investigate current evidence-based neuromuscular screening tools, distilling information of the most relevant for the female youth grassroots game
2. Design and analyse a survey, distributed to technical coaches of youth football, investigating potential barriers, facilitators and their knowledge and confidence regarding the use and implementation of NSTs
3. Conduct semi-structured interviews and co-production focus groups specifically for coaches of the female youth grassroots game investigating potential barriers, facilitators and their knowledge and confidence regarding the use of and implementation of a novel NST for use with their participants
4. Conduct semi-structured interviews and co-production focus groups specifically for coaches of the female youth grassroots game seeking their guidance and insight in the design and development of a novel NST educational session
5. Using the RE-AIM framework, design, conduct and evaluate a NST educational session for coaches of female youth grassroots footballers, providing recommendations for future developments

1.2 Thesis organisation

Chapter 2 reviews existing literature and critically analyses topics relevant to this thesis, including the benefits of grassroots sport, injury prevalence and mechanisms in female adolescent football, identification of heightened injury risk or reduced movement competencies, and coach education strategies.

Chapter 3 explores baseline information from coaches about NSTs and coach education programmes using surveys and interviews. It investigates coaches' knowledge, confidence, perceived barriers and facilitators, and preferred CPD formats. A focus group helped co-develop the final NST tool. The chapter concludes by integrating coach perspectives with relevant literature to shape the final coach-led NST tool.

Chapter 4 pilots this tool with grassroots coaches of female adolescent footballers and draws conclusions about its effectiveness.

Chapter 5 summarises the thesis and provides recommendations for best practice in the female grassroots game, as well as suggesting areas for further research.

Chapter 6 discusses the appropriateness of using NSTs in this context and outlines recommendations and a proposed roadmap for implementation.

Chapter 2: Literature review

2.1 The grassroots game

Female football participation in both England and around the world has continued to increase in popularity, in both the professional game as well as academy and grassroots level (The Football Association, n.d). In 2013, there was estimated to be over 29 million female football players worldwide (Martínez-Lagunas et al., 2014). In 2015, the FA released figures showing that there were 2.5 million female players registered in England, a figure that increased to 3.4 million in 2020 (The Football Association, n.d.). Moreover, as 63% of schools in England now offer equal access to football during PE lessons for girls to play football (The Football Association, 2021a) many more participants may play regularly for non-affiliated clubs, in schools or recreationally. Sport England's Active Lives Children and Young People Survey 2021-2022 found that a third of female respondents highlighted that they regularly participated in football-related activities, with peak participation being between 8-12 years old (The Football Association, 2021b).

2.1.1 The value of grassroots youth sport

The FA report 'The Social and Economic Value of Grassroots Football in England' (The Football Association, 2021b) categorised the value of grassroots football into three themes; Economic Impact, Social Impact and Health Impact. The social and economic benefits of community sport and physical activity contribute an estimated £85.5 billion to the economy (National Audit Office, 2022).

2.1.1.1 The economic impact of grassroots youth football

From a solely economic view, sport and physical activity contributes over £39 billion to the economy annually, the majority of which is generated via grassroots sports through the purchase of equipment, memberships or other associated costs (Economic Development, Sport England, n.d.). Further economic contributions are seen through the reduction in both healthcare costs and crime (Economic Development, Sport England, n.d.). Whilst grassroots football contributes approximately £10 billion annually to the English economy (Birdsall-Strong, 2022), child-specific grassroots involvement alone contributes £2.42 billion (The Football Association, 2021b). The largest proportion of this economic impact (£1.20 billion) is generated via the positive effects of the 70,000 adults who formally volunteer in grassroots football (The Football Association, 2021b). This income adds to the £560 million of financial contributions (i.e. taxation etc.) from the 155,000 coaches and 27,541 referees who are employed directly in a role that supports youth football (The Football Association, 2021b). A further £660 million is generated through participation costs such as equipment costs, membership costs and parental / guardian financial outlay (The Football Association, 2021b).

2.1.1.2 The social impact of grassroots youth football

The benefits of grassroots sport, particularly football, extend well beyond financial gains. Grassroots sport is believed to enhance health and wellbeing, boost education and learning, foster social interactions, build leadership skills, confidence, and resilience, and even advance peace via 'diplomacy through sport' (Garamvölgyi et al., 2022). Grassroots sport can serve as a powerful force for positive change, aiding participants in forging and strengthening social connections while fostering a sense of belonging within their communities (Thorpe, 2021). Such social interactions cultivate trust among individuals, boosting social cohesion and trust levels by 5% compared to the general population (The Football Association, 2021b). Furthermore, grassroots youth football

enhances social mobility and provides participants with more frequent opportunities to engage with individuals from diverse cultural and socio-economic backgrounds than is typical in the general population (The Football Association, 2021b).

Participation in grassroots sports can aid the reduction in crime, including reoffending rates, with a conservative estimate of saving the economy £6.5 million per year (Meek, 2018; The Football Association, 2021). Personal development through grassroots youth football can be seen via improved levels of self-confidence, self-esteem and self-efficacy. Additionally, participation in grassroots football can help develop transferable skills in young performers, such as leadership skills. These skills, combined with the enhanced educational attainment previously mentioned, contribute to greater employability and earning potential for individuals who participate in sports compared to those who do not (Griffiths et al., 2017).

Social interaction enhances the enjoyment of football participation, increasing intrinsic motivation to continue playing, thereby developing adherence in the short and long term. However, the competitive nature of football may mean that some individuals may be excluded from this social circle (and indeed the benefits of participation in grassroots football) due to having underdeveloped technical skills, which may be seen to potentially have a negative impact on overall team performance. Additionally, football clubs may not be as inclusive if they believe that new participants may disrupt the social balance of the club (Nielsen et al., 2014).

2.1.1.3 The health impact of grassroots youth football

Among children aged 5 to 18 who participate in football, 65% meet the government's physical activity guidelines, which recommend at least 60 minutes of physical activity each day (The

Football Association, 2021b). Sustained physical activity levels help reduce the prevalence of childhood obesity and its associated annual cost of nearly £9 million to the NHS (The Football Association, 2021b). Obesity is often linked with additional health issues such as coronary heart disease, diabetes mellitus, arthritis, dementia, and certain cancers (Pi-Sunyer, 1999). Active children are more likely to continue these habits into adulthood, so promoting healthy behaviours through grassroots youth football could potentially save the NHS an additional £511 million in future years (The Football Association, 2021b; Ward et al., 2017). For females, participating in grassroots sports may also help reduce the risk of osteoporosis (Bailey et al., 1999).

The health benefits of continued participation in grassroots football extend beyond physical fitness to impact mental health and overall well-being (Ströhle et al., 2007). Engaging in football has been shown to reduce the prevalence of mental health disorders in children by 30% (Ströhle et al., 2007). This advantage is particularly significant given the rising rates of teenage suicide (Iacobucci, 2020). Since mental health issues often begin in childhood or adolescence and can persist into adulthood, reducing these conditions early can decrease their prevalence in later life (Kessler et al., 2005), partly due to involvement in grassroots football.

It is crucial to balance the mental and physical health benefits of grassroots youth football with the potential risks of injury. Football inherently carries a risk of injuries that could lead to long-term issues such as early knee osteoarthritis, Osgood-Schlatter disease, or Sever's disease (Clausen et al., 2014; Le Gall et al., 2008). Injuries also contribute to both short-term and long-term healthcare costs for individuals and governments (Watson & Mjaanes, 2019). With the rising incidence of football-related injuries in youth players (Esquivel et al., 2015; Smith et al., 2016), it is essential to focus on injury prevention to minimise long-term disability. Investigating methods to prevent serious football-related injuries is crucial (Myer et al., 2008; Watson & Mjaanes, 2019).

Notably, female players face a four- to six-fold higher risk of ACL injuries compared to males, potentially due to differences in neuromuscular development during puberty (Davidson & McLean, 2016; Myer et al., 2008; Quatman et al., 2006). Therefore, implementing neuromuscular screening and training could help reduce the economic and social impact of injuries in youth football. Unlike in elite football, where specialised staff handle player health, grassroots coaches typically bear the responsibility for ensuring participant well-being (White et al., 2012).

2.1.2 The grassroots coach

In contrast to high performance sport, the grassroots coach aims to develop and maintain participation through the enjoyment of the player and may value the health-related benefits of participation objectives above performance and success at competitions (Côté & Gilbert, 2009). Côté and Gilbert (2009) further detail the objectives of the grassroots coach as (1) promote fun and enjoyment during training and competition, (2) enhance opportunities to increase fitness and health through participation, (3) develop sport specific skills, (4) develop interpersonal and social skills through sport (5) enhance long term sporting involvement.

Whilst it is recognised that grassroots sport participation is mainly focused on fun and enjoyment, the competitive element of grassroots sport also requires a coach to develop players in attributes such as physical and technical ability and mental skills (Côté & Gilbert, 2009). It is emphasised that all the above are to be completed in a safe manner and in a safe environment (Côté & Gilbert, 2009). Ultimately, without the consistent support of on-site medical professionals, the job of keeping participants safe during practise and competition falls to the grassroots coach and their national governing bodies of sport (NGB) (Micheli et al., 2000).

The United Kingdom Coaching Certificate (UKCC) was established to ensure standardisation of the quality of coaching qualifications across a variety of sports. The structure established via the UKCC framework has four main progressive levels (Twitchen & Oakley, 2019). However, recently, this has been realigned to make three levels, with a greater emphasis on coaching attributes and skills rather than linear progression (Figure 1).

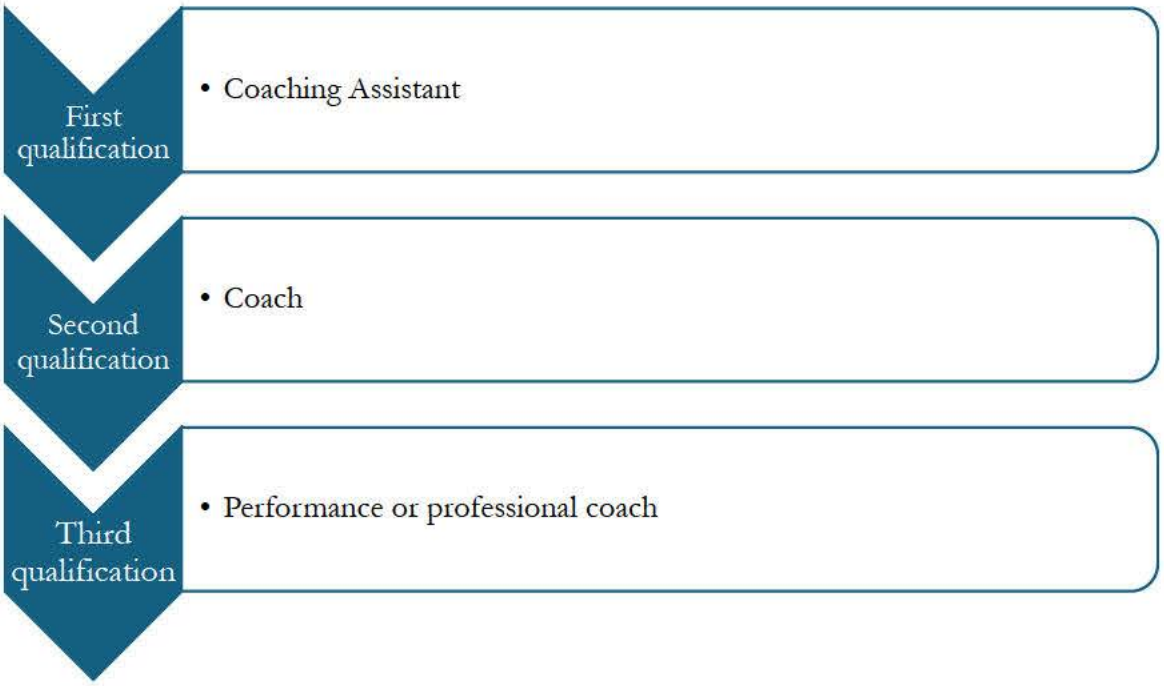


Figure 1. UK Coaching qualification structure, adapted from UK Coaching, (n.d.)

It is noted that there is no formal requirement for coaches to progress to a higher level if continuing to coach the same players. As there are no requirements to undertake continued professional development (CPD), a coach may have achieved their Level 1 qualification many years ago, yet may not have updated their skills or knowledge formally since that point (Lara-Bercial et al., 2020).

It is the responsibility of NGBs of sports, such as the FA, to operate and certificate qualifications at Level 1 and Level 2 independently, with coaching awards at Level 3 and above usually offered in collaboration with an educational institution such as a university. This 'ownership' for Level 1

and Level 2 coaching qualifications by NGBs could potentially lead to stagnation of the qualification's continued development and improvement (Twitchen & Oakley, 2019).

In terms of FA coaching qualifications, these are banded (Figure 2).

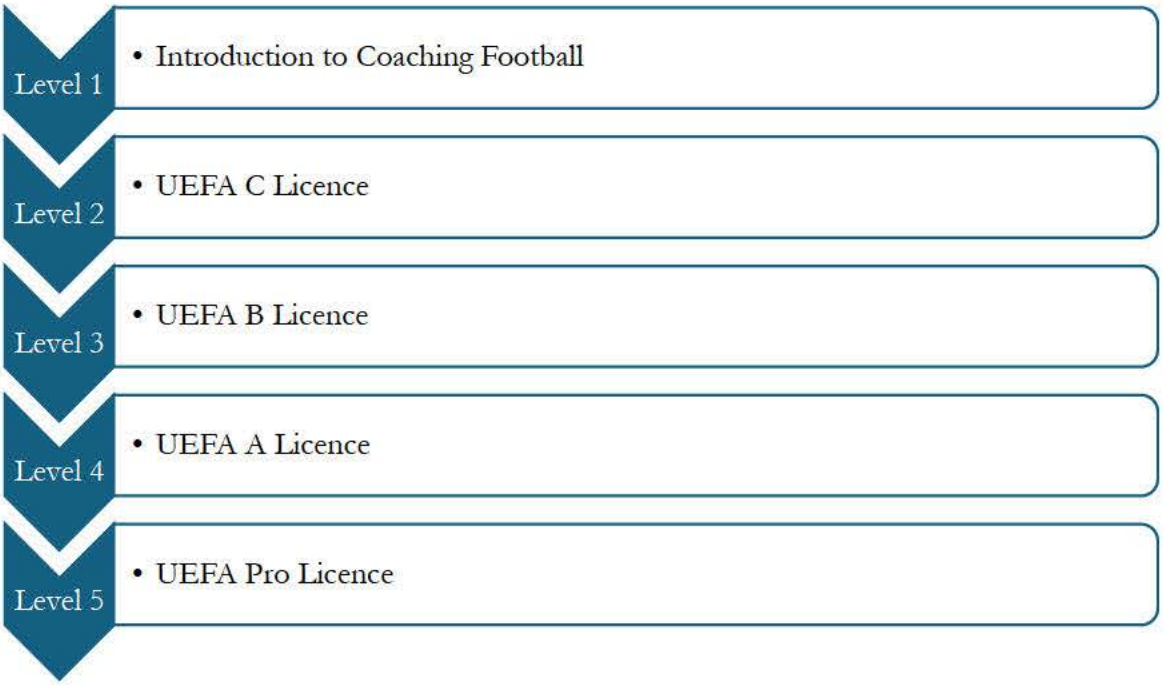


Figure 2. FA football coaching qualifications, adapted from The Football Association. (2025).

2.1.3 Section summary

Of the 155,000 active football coaches in England, 16,210 coach in the female game (The Football Association, 2021a). Participation in female football continues to grow globally and in England across all levels. Grassroots football delivers significant economic, social, and health benefits, fostering community cohesion, building confidence, and enhancing employability, while also reducing crime and promoting inclusion. Health benefits include improved physical and mental well-being, with active children more likely to maintain these habits into adulthood, reducing healthcare costs. However, risks such as injuries, particularly for female players, highlight the need

for injury prevention strategies. Grassroots coaches play a pivotal role in ensuring participant safety and fostering enjoyment, yet challenges remain in this aspect due to limited formal CPD requirements. The FA's efforts to standardise coaching through qualifications help address these issues, but further development is needed to optimise these areas.

2.2 Injury risk in female youth football

2.2.1 Defining "injury" and injury recording

Despite the widespread reporting of injury incidence within adolescent football, there is wide variation in the definition of what constitutes an "injury" (Venturelli et al., 2011). This ambiguity may lead to differences in reported injury incidence, injury locations and injury severity factors (Fuller et al., 2006). A consensus statement on injury definitions and data collection in football studies stated that an injury should be defined as: "Any physical complaint sustained by a player that results from a (football) match or training, irrespective of the need for medical attention or time-loss from football activities" (Fuller et al., 2006, p. 84). However, this definition potentially allows perceptions of injury severity to influence research, as, if we accept the injury definition of Fuller and colleagues (2006) the only person who can determine if an injury has occurred is the player themselves (Clausen et al., 2014). If, for example, the "injured" participant believes the injury to be worse than it is (i.e. potentially due to past personal experience), they may decide to miss more training than a player who believes the same injury is not that severe. As a result, researchers may record time lost due to injury (such as a hamstring injury) which is disproportionate to the physiological muscular damage. Venturelli et al., (2011) highlights that authors in this field may instead use objective assessments, rather than participant-led subjective injury classification definitions, such as a physiotherapist-led Lachman Test for ACL injury. Yet

the objective medical approach is problematic, as the likelihood of a lack of qualified medical support available to diagnose an objective medical injury within the grassroots game is lacking, which potentially explains why only 25% to 31% of injuries result in qualified medical intervention (Emery, 2003). It is for this reason that mild injuries (under 20 days absence) may be under-reported, with more notable and severe (>20 days) injuries being overestimated (Faude et al., 2013).

The ambiguity around the definition of an injury within this field further complicates the process of accurate injury recording, which may be overestimated or underestimated depending on the reporting source (Emery, 2003). For example, if an injury is defined as when a participant receives treatment at a medical facility, this may underestimate injury recording, especially in the grassroots arena where medical treatment is limited unless the participant is taken to a medical facility. Studies may overestimate injury rates if they include injuries reported by a coach or a parent of the participant without the need for medical attention (Emery, 2003), whilst self-reporting injury prevalence may be underestimated (Schiff, 2007). Furthermore, studies seeking to establish injury prevalence via retrospective self-reporting of a cohort may suffer from recall bias with incident rates being underestimated more significantly if the recall window is larger (Fuller et al., 2006; Read et al., 2018). Additionally, recall bias could be influenced by the nature of injury. For example, recurrent injuries (which accounts for 46% of all injuries, Clausen et al., 2014), such as a persistent hamstring injury will potentially be documented more often than an isolated ankle sprain. Moreover, logic suggests that a significant injury such as a bone break or tendon/ligament rupture would be recalled on every questionnaire, whereas less significant injuries may not all be recalled at all.

Issues with injury reporting data in youth football may exist due to the broad definitions of what constitutes an injury in research. For example, Fuller et al., (2006) notes that a player may be absent

from a game/training (and are thus classified as "injured") when their absence is not a result of a musculoskeletal condition (such as illnesses, diseases or mental health conditions). In addition to the ambiguity regarding the definition of an "injury", there are other methodological issues with injury reporting in youth football. For example, due to practicalities, researchers are sometimes unable to report injuries lasting <48 hours due to lack of contact with participants during that time (Price et al., 2004). This timeframe is extended further for grassroots participants, making accurate data collection for this cohort even more problematic (Froholdt et al., 2009; Rössler et al., 2016a). Moreover, injury incidence may naturally be inflated through adolescence due to situational exposure (such as increased game/training intensity), which is not often considered. For example, as players age, they move up from 7 vs 7 games to 11 vs 11 games, thus increasing training/game load and the opportunity for player-to-player contact, potentially resulting in increased injury incidence (Price et al., 2004). Finally, in-competition injury reporting may overestimate injury incidence due to the assumed higher intensity of competitive games versus training (Emery, 2003).

2.2.2 Females vs. males injury incidence

Research into female football, especially female youth football, is sparse when compared to studies investigating male football (Cumming, et al., 2006). It is well documented that female football players are at a greater risk of injury compared to their male counterparts, with injury sustained during football being the leading cause of sport-related injury in young female athletes (Rumpf & Cronin, 2012; Barber Foss et al., 2018). Injury rates for boys' football have been shown to be between 1.2 to 6.8 injuries per 1,000 hours of football-related activity (Brito et al., 2012). However, some studies note that injury incidence rates for boys are slightly higher than those for girls playing football (2.2 vs 2.0 injuries per 1,000 hours of football-related activity for boys and girls, respectively, Froholdt et al., 2009). Injury incidences rates of between 9.1 and 24 per 1,000 hours of football-related activity have been previously reported for junior female football players (Le

Gall et al., 2008). However, this has been contradicted by reports of lower injury incidence rates of between 2.2 and 6.4 per 1,000 hours of football-related activity (Emery, 2003; Schiff 2007; Froholdt et al., 2009). This discrepancy may be related to data collection techniques of the authors and whether injury is reported by the player (Schiff, 2007) or by a responsible adult (Rössler et al., 2016a). Although the use of a player/parent-administered questionnaire may affect the accuracy of incidence recording (Emery, 2003), Schiff et al., (2010) found agreement between the use of parental injury logs and those completed by qualified trainers and therapists, an argument supported by the similarity to the incidence rate reported by Le Gall and colleague's (2008) study that used objective medical assessments.

Although injury incidence rates of up to 90 per 1,000hr of football-related activity have been shown for young female football players (Sentsomedi & Puckree, 2016), the absence of detail regarding how the researchers quantified an injury (reported via a player-completed questionnaire) raises questions about the validity of these higher rates. Furthermore, although Froholdt et al., (2009) maintains adolescent football participation poses a low injury risk, Sentsomedi and Puckree (2016) found that 94% of their participants reported an injury during the study window. Clausen et al., (2014) concluded that injury incidence rates are, in fact, "very high" in adolescent female football (incidence rate of 15.3 per 1,000hr), yet themselves report rates far lower than the figure reported by Sentsomedi and Puckree (2016). Of note, Clausen and colleagues (2014) outlined their definition of injury, by way of a four-weekly text message survey, as a new onset of pain. Clausen et al., (2014) further divided injury into time-loss and non-time-loss injuries. Time-loss injuries are those where the participant can no longer play games or train, where non-time-loss injuries require no reduction in football participation. Incident rates for time-loss injuries were greater than those of non-time-loss injuries (9.7 vs 5.6 per 1,000hr of participation). Although time-loss incidence rates were greater than non-time-loss incidents, the higher incident rate reported by Clausen et al., (2014) could be due to the definition of injury used. Although Clausen and colleague's injury

definition corresponds with the definition outlined by Fuller et al., (2006), researchers such as Schiff (2007) did not include non-time-loss injuries within their research, reporting only days lost due to injury (the highest proportion being 10 days or more). Additionally, Rössler et al., (2016a), also refrained from recording injuries that did not result in the withdrawal from participation, thereby possibly explaining the "very high" risk in adolescent female football asserted by Clausen et al., (2014). The methodical differences in defining what constitutes an 'injury' coupled with alternative methods of collecting injury data makes drawing solid conclusions problematic.

2.2.3 Injury type and location

Approximately 50-70% of football injuries occur to the lower extremities, especially to the knees and ankles (Lehr et al., 2013; Rumpf & Cronin, 2012). In a review of studies investigating football injuries in youth participants, the ankles and feet were the most common injury sites recorded (13-22% and 8-28% respectively) followed by the upper thigh (1-21%) and knee (10-18%) (Faude et al., 2013). The main injuries reported during football were muscle and tendon strains, ligament sprains and contusions, with adolescent females suffering more ligamentous sprains than muscular strains (27–47% vs. 15–25% respectively) (Faude et al., 2013; Watson & Mjaanes, 2019). A two-year longitudinal study cataloguing injury incidents in over 395,295 youth football players found that joint and ligament injuries (i.e. ankle sprains) were the most common injury reported, followed by contusions and muscle / tendon injuries (Rössler et al., 2016a).

Despite previous discussion showing that 1) less serious injuries (i.e. strains and sprains) occur more frequently, and 2) the knee is not the most injured site in youth footballers, there seems to be unequal focus on ACL injury in female football (Herman et al., 2012). However, when further categorising injury locations by severity, Clausen et al., (2014) found that in adolescent females, the knee was the most common injury site resulting in time-lost from football-related activities

(25%), followed by the ankles (20%). Further analysis found that the knee was the location of the most severe injuries (37%), again followed by the ankle (17%). It is therefore unsurprising that the serious nature of these injuries is the focus of numerous studies. However, ACL injury, although serious, is a rare occurrence when studying youth female football players, with only 0.5% of players over a season being affected by this injury (Hägglund & Waldén, 2016). Hägglund and Waldén's (2015) study population of over 4,500 players adds credence to the ability to generalise these findings to the wider populace. Only two players throughout their study suffered an ACL injury. However, the lack of ACL injuries reported may be directly related to the lower proportion of females included in the study of Rössler et al., (2016a), with only 3.9% of participants being female. Moreover, the authors themselves also cite limitations, hypothesising that training and match frequency may have resulted in under reporting of injury. This is pertinent to the grassroots game as there are longer durations between football-related activities at grassroots level than at academy level, suggesting a potential underreporting injury trend at lower playing levels.

Many studies investigating injury types and location suffer from low sample sizes (and thus reduced reported injury incident rates), making generalisation challenging (Herman et al., 2012). This is particularly the case for female participants under the age of 13 years old (Faude et al., 2013). To enable more accurate data recording, specific anatomical locations (the specific muscle or ligament) should be recorded as well as "thigh", "knee" etc (Fuller et al., 2006). However, given the lack of qualified medical expertise at youth football, this recommendation may be challenging for researchers to adopt.

2.2.4 Injury vs. playing age group

Focusing purely on injury and playing age shows that the injury rates of youth female footballers approach similar levels to more senior females such as older teenagers and adults (who are playing

11-a-side football as opposed to 5-or 7-a-side football) around the ages of 12-14 years old (Hägglund & Waldén, 2015; Faude et al., 2013). Injury rates for those younger than 12 years old are low (Hägglund & Waldén, 2015), however this conclusion may be because of limited research on this specific population (Faude et al., 2013). As playing age increases so does the incidents of player-to-player contact, thus is a possible contributing factor to explain the correlation between playing age and injury rates (Gianotti et al., 2009).

2.2.5 Injury vs. playing level and type

There are conflicting findings regarding injury and playing level (Clausen et al., 2014; Soligard et al., 2010). Whilst no link between playing level and risk of time-loss injuries in adolescent female football players has been reported (Clausen et al., 2014) others do report a link between playing level and injury risk, in that the higher the level played, the greater the injury risk (Soligard et al., 2010; Hägglund & Waldén, 2015). Whilst both the studies of Clausen et al., (2014) and Soligard et al., (2009) collected injury data retrospectively and had high participant numbers, the study of Soligard et al., (2010) had three-times greater participants than Clausen et al., (2014) (1665 vs. 438), Soligard et al., (2010) noted that injury data was not collected at the same time as skills data (to ascertain playing level), which therefore may explain some of this disparity as the skill level recorded may have progressed (and was recorded) since the time that the injury occurred.

When noting a link between playing level and injury risk, Soligard and colleagues (2010) hypothesised that higher level players would participate in a greater number of competitive games, which may contribute to increased injury incidence. Price (2004) found that certain injuries (contusions) occurred more frequently in competition rather than training sessions potentially due to increased game intensity and speeds during competition resulting in more (and more forceful) player-to-player contact (Emery, 2003). However, there are some exceptions. For example, Price

(2004) found a greater proportion of muscle strains (particularly to the thigh), during training compared to competitive play. Similarly, Soligard et al., (2010) reported that there was a negative association between training load and injury incidence, in that greater exposure to training reduced injury risk, with this protective mechanism potentially conditioning higher-level performers against injury. Additionally, Clausen et al., (2014) found that those who were engaged in football-related activities only once per week were more at risk of injury. The authors did acknowledge that one potential reason for this association could be that those who participate irregularly did so due to already having an injury. Nevertheless, as grassroots footballers participate less regularly than their higher-level peers (i.e. academy level), this link should raise concerns for those involved in the game. Conversely, Venturelli et al., (2011) found that there was no association between football-related activities (training and matches) and injury (thigh-strain), concluding that there is no difference in injury risk in relation to playing level for children and adolescent footballers. However, a low sample size compared to the previous studies may explain the lower incidences of injuries reported during their study. Whilst there are undoubted links between age (and thus playing level) and injury in female youth football as noted above, the mechanisms of injury and the role that maturation and other intrinsic and extrinsic factors have on injury incidence require more detailed discussion.

2.2.6 Mechanisms of ACL injury

Significant research has investigated the mechanism of ACL injury in adolescent female participants (Hägglund & Waldén, 2015; Alentorn-Geli et al., 2009; Quatman et al., 2006). Researchers have pointed to muscular imbalances, flexibility issues, delayed neuromuscular development and recruitment, changes in body shape and size, hormonal, chemical and endocrine development as injury risk predictors (Alentorn-Geli et al., 2009; Myer et al., 2008). Whilst discussion of a variety of these theories will be outlined, it is noteworthy that there is unlikely to

be one singular mechanism of injury for an injury event. Indeed, injury will more likely occur due to a combination of factors, including, but not limited to biomechanical, anatomical, anthropometric, hormonal and neuromuscular development (Hägglund & Waldén, 2015; Quatman et al., 2006). However, many of the mechanisms of injury that will be described are influenced by maturation of the female participant. As noted previously, it is during this period of development that injury incidents for male and female participants diverge. Of note, most of the mechanisms of injury discussed below relate to injury of the ACL. It has been previously highlighted in this dissertation that injury to the ACL, although not as common as lower-limbs sprains or strains, has a significant impact on quality of life for the participant (Fox et al., 2017). Thus, literature on the mechanisms of injury disproportionately focus on the ACL and hence are discussed below.

Risk factors of lower extremity injury in female football has been broken down into two areas; extrinsic and intrinsic. Extrinsic factors are commonly defined as risk factors external to the individual and that they have limited control over. Such factors, including the environment and equipment, are outside of the scope of this review. Intrinsic risk factors are related to the internal workings of the individuals' body and are broken down into anatomical, hormonal, biomechanical and neuromuscular (Alentorn-Geli et al., 2009).

2.2.6.1 Anatomical risk factors

2.2.6.1.1 Flexibility

Reduced range of motion may lead to increased injury (Verrall et al., 2007). In a study using male participants Cejudo et al., (2015) found that although flexibility may correlate to performance indicators, they were unable to conclude as to whether flexibility influences injury rates. Verrall et al., (2007) contend that a reduction of flexibility in the muscles of the hip and leg may increase the likelihood of recurrent groin injury. However, participants in Verrall and colleagues' study were

adult males (mean age = 21.4 years old) which may not be generalisable to adolescent female performers. During adolescence, flexibility and joint laxity decrease in males and increase in females (Myer et al., 2008). If flexibility is an injury risk identifier, it may be argued that rather than a lack of flexibility being an injury risk factor, an increase in flexibility may be a predictor of higher injury risk. Myer et al., (2008) citing Ford et al., (1997) reported that increased flexibility may lead to a delay in the co-contraction of the hamstrings and quadriceps. Myer et al., (2008) postulated that this delay may result in decreased knee flexion in the sagittal plane, predisposing participants to increased injury risk.

In elite male footballers Witvrouw et al., (2003) identified reduced flexibility in the quadriceps and hamstring muscle groups as a risk factor for players. With a sample of 146 participants, researchers reported 31 and 13 injury occurrences during the sampling window for the hamstring and quadriceps groups, respectively. This proportionally low occurrence rate may add additional credence to the view that reduced flexibility may not be a significant injury risk predictor in football players. Indeed, a systematic review failed to conclude on the benefits of flexibility training used to reduce injury risk, pre or post competitive or recreational sporting participation (Thacker et al., 2004). Overall, researchers proport issues with flexibility imbalances, hyperextension and low hamstring-to-quadriceps strength ratio (H/Q_r) as a greater injury risk identifier then flexibility of a muscle group alone (Söderman et al., 2001).

2.2.6.1.2 Pelvis and Q-angle

The inability of the hamstring group to prevent quadriceps-induced anterior tibial shear may not solely be because of H/Q_r imbalances. Other mechanisms that may limit the hamstring group's ability to prevent knee movement include an anteriorly rotated pelvis (Delp et al., 1999). Furthermore, an anteriorly rotated pelvis can influence lower-limb mechanics, increasing knee valgus and pronation of the foot, potentially due to decreasing the strength of the gluteus medius

muscle (Alentorn-Geli et al., 2009). Both mechanisms have been linked to increased injury prevalence (Hopper et al., 2017; Myer et al., 2009). These conclusions are not universally supported however, with Nilstad et al., (2014) finding no correlation between knee valgus angles and knee injury. The authors themselves were surprised by this finding, attributing the discrepancy between the results and most of the literature to their specific cohort (playing level).

The Q-angle (Figure 3) is defined as the angle between two lines, firstly from the anterior-superior iliac spine to central patella and the second line directed from the central patella to tibial tubercle (Alentorn-Geli et al., 2009). This naturally occurring anatomical feature may increase injury risk due to altered biomechanics which increases valgus load moments at the knee, with a greater Q-angle correlating to higher knee injury incidence (Alentorn-Geli et al., 2009). However, although limited research supporting this hypothesis exists, there was no association between the Q-angle and leg injuries in female footballers (Söderman et al., 2001).

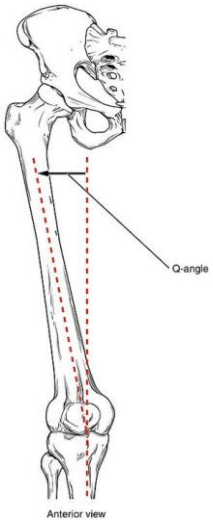


Figure 3. Q-angle (Physio-pedia.com, n.d.)

The size of the femoral intercondylar notch has been muted as an injury risk indicator (Quatman et al., 2006). Researchers report that the stenosis of the femoral notch was related to increased

injury risk, independent of sex (Myer et al., 2009), although this is surprising given that females have on average, narrower femoral intercondylar notches (Hewett et al., 2010). Additionally, Hewett et al., (2009) suggests that a narrow femoral notch is potentially an inherited trait, with a narrower notch potentially leading to impingement of the ACL. In their longitudinal study of military recruits, Uhorchak et al., (2003) found narrowed femoral notch width as one co-contributing risk factors of ACL injury, a risk factor that can also be extrapolated to sports performers. Where other studies have also confirmed the link between femoral notch width and ACL injury risk, studies suffer from lack of generalisability due to their use of cadavers for modelling (Alentorn-Geli et al., 2009). Dienst et al., (2007) found femoral notch width correlated with ACL cross-sectional area. The smaller the femoral notch width, the smaller the ACL. The smaller the ACL cross-sectional area, the less ability the ACL will have to withstand load (Davidson & McLean, 2016). Whilst this general theme is accepted, how the size and structural properties of the ACL develop during maturation is less understood and requires further investigation (Davidson & McLean, 2016).

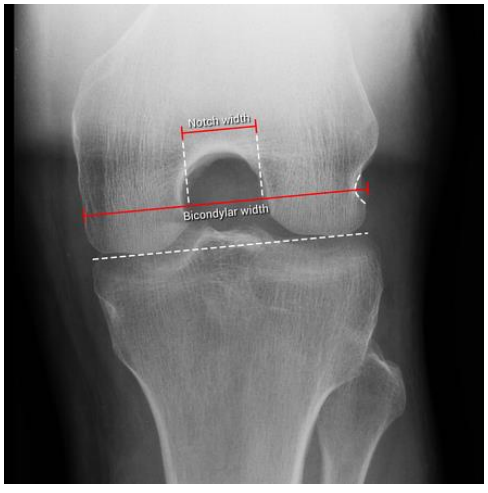


Figure 4. Femoral intercondylar notch (Radiopaedia.com n.d.).

2.2.6.1.3 The influence of body mass / BMI as a co-contributor

Different biomechanical movement patterns may contribute to injury and help to explain the divergence of injury risk between male and female sporting participants during puberty. Females display reduced knee flexion, greater hip and knee transverse and frontal plane motion compared with their male counterparts (DiStefano et al., 2015). These motions are of importance due to their role in movements such as landing or directional changes (Gianotti et al., 2009). DiStefano et al., (2015) reports that differences in landing kinematics during maturation increases injury risk for females due to reduced sagittal plane motion – landing in a more upright position – potentially because of a lack of increase in quadriceps strength to counteract increases in BMI.

Increased Body Mass Index (BMI) coupled with a narrow femoral notch, and increased BMI, body fat percentage and fat free mass contributes to injury risk, differentiating between male and female participants (Uhorchak et al., 2003; Kemper et al., 2015). Increases in ground contact loading during maturation may increase injury risk (De Ste Croix et al., 2018). Ground contact loading could be due to increase in absolute and proportional fat mass in adolescent females seen during maturation without the comparative gains in muscle mass and skeletal tissue (Cumming et al., 2006; Quatman et al., 2006). In a study of over 200 elite level football players, Nilstad and colleagues (2014) found a significant correlation between BMI and lower-limb injury, in that, players with a higher BMI had a greater prevalence of injury. Specifically, BMI was associated with thigh injuries, which may potentially be because of a lack of dynamic strength increases, proportional to BMI increases (Nilstad et al., 2014). The association between injury incidence and BMI alone may be erroneous unless researchers account for normal growth and maturation, as increased growth will also change the body's centre of mass, potentially increasing forces through the joints as well as altering neuromuscular control (Quatman et al., 2006). Kemper et al., (2015) confirmed injury risk factors including increased BMI and low (not high) body fat percentage. Although the study of Kemper et al., (2015) included only male football players, other researchers have reported similar

findings with a cohort of youth female footballers, with females with a higher BMI having a 1.4 times increased incidence of previous injury (Sugimoto et al., 2018). Researchers have reported a similar link between BMI and injury prevalence in adolescent females, with BMI correlating to increased injury risk, as females do not naturally adjust landing kinematics during maturational development, increasing kinematics forces on the lower-limbs (Alentorn-Geli et al., 2009; Quatman et al., 2006). Additionally, a contributing factor to an increase in BMI during puberty is rapid bone growth. This increase in bone growth results in increased joint levers, potentially increasing the torsional forces acting within and on the joints, heightening injury risk (Quatman et al., 2006).

In a study of over 1,000 participants, BMI was a differentiator for ACL injury risk between male and female footballers over the age of eight years old (Yund et al., 1998). More recently, Richmond et al., (2016) linked injury to BMI in adolescents (mean age 13 years old). Using secondary data from a previous study, Richmond and colleagues found that an increase in BMI resulted in a 34% increase in injury risk. However, questions could be raised as to the collection methods for injury reporting, being a mix of historical questionnaires coupled with absence from participation. As previously noted, self-reporting injury questionnaires are open to exaggeration and withdrawal from participation, and thus may not correlate with injury severity or presence.

There are many authors who have failed to corroborate the findings of Hewett and colleagues (2006) (Yund et al., 1998; Richmond et al., 2016). The work of Fuller et al., (2006; 2007), and Kucera et al., (2005) found that although injury risk was higher with increasing BMI, this correlation became weaker when corrected for gender and playing position. It could therefore be suggested that although evidence generally points to a link between increased BMI and injury, the data is unable to support these conclusions. Where this link is maintained in research often

additional variables have not, or cannot be accounted for (i.e. the influence of increased weight on biomechanical and anatomical forces).

2.2.6.1.4 Joint / ligamentous laxity

Previous research has concluded that females with a greater degree of joint laxity (especially when compared to their male counterparts) have a 2.8 increased risk of injury, (specifically to the ACL) (Uhorchak et al., 2003). In their study, Myer et al., (2008) found that specific movements of the knee associated with increased ligamentous laxity (knee hyperextension and side-to-side differences in anterior/posterior tibiofemoral translation) was identified as a risk factor for future ACL injury. However, joint laxity may not be solely a risk factor for knee ligamentous injuries as increased joint laxity is an indicator of all-types of lower-limb injury (Ostenberg & Roos, 2000; Söderman et al., 2001). Although Söderman and colleagues use the Lachman test in order to identify joint laxity (a test that could provide erroneous results in the case of increases in humidity or temperature - Herzberg et al., 2017), this was only one of three joint laxity tests completed, helping to validate these results. Like the influence of BMI, Söderman cites the challenges of studying an independent injury risk factor (in this case joint laxity) in isolation, as other contributing factors such as H/Q_r or low postural sway of the legs could influence findings. Of note however, is the link between increases in knee injury in female football players and general increases in joint laxity in females vs. males (Park et al., 2008). These links suggest that increased joint laxity in females contribute to overall risk of lower-limb injury when compared to males as increased laxity could alter the mechanics of movement and landing, but more studies are needed if the independence of this risk factor is to be clarified (Alentorn-Geli et al., 2009).

2.2.6.1.5 Anatomical risk factors – summary

A variety of anatomical risk factors related to injury risk (mainly to the ACL) have been discussed. Whilst some of these risk factors could be moderated (BMI), others are inherited and unchangeable (pelvis size, Q-angle, femoral intercondylar notch and ACL size). Some risk factors require more research to strengthen their association with injury risk in footballers (Q-angle, joint laxity), whereas others (BMI, ACL cross-sectional area) have been consistently reported as heightening injury risk. Flexibility has generally not been a significant injury risk factor in football other than for minor muscular strains. Consistent throughout research are authors' assertions that risk factors should be considered in association with other factors, for example, how an increase in BMI may change the biomechanical forces through the joints.

2.2.6.2 Hormonal and endocrine contributors

Hormonal influences and cyclic fluctuations have been hypothesised to predispose female athletes to increased injury risk (Quatman et al., 2006; Myer et al., 2009). The three phases of the menstrual cycle are the follicular (day 0–9), ovulatory (day 10–14) and luteal (day 15–28) (Alentorn-Geli et al., 2009). A systematic review found that female participants are more predisposed to ACL injury in the preovulatory phase of the menstrual cycle due to the increased levels of the hormone progesterone (Hewett et al., 2007). Oleka (2020) states that the "first half of the menstrual cycle is also a vulnerable time for anterior cruciate ligament injuries because of the effect of hormonal fluctuations on biomechanics and laxity of ligaments" (p. 110). Oestrogen influences both muscular function and ligament strength (Hewett et al., 2006; Sarwar et al., 1996). It was postulated that increased levels of oestrogen around the time of menses onset may influence neuromuscular function, potentially increasing knee abduction (Myer et al., 2009). Other researchers (Hertel et al., 2006) however, report that injury risk is higher during the ovulatory phase itself which is at the point that both progesterone and oestrogen concentrations are comparatively low (Vescovi, 2011). Vescovi (2011) outlines one theoretical link between hormonal concentration and injury due to

hormonal influence on collagen metabolism, as evidenced by differences in the cellular remodelling process of ligaments between males and females. Additionally, oestrogen has been identified in fibroblasts in humans, suggesting a link between oestrogen and human tissue-forming cells (Vescovi, 2011). However, most of the research investigating the influence of hormones on the mechanical properties of ligaments have been conducted on animals and not humans (Alentorn-Geli et al., 2009).

Research has also investigated the role of sex hormones on neuromuscular control and joint laxity. A systematic review reported differences in knee laxity between days 1-9, 10-14 and 15-28 days of the menstrual cycle, with days 10-14 being the timing of greatest laxity (Zazulak et al., 2007). A review by Balachandar et al., (2017) partially corroborated these findings. After reviewing 17 articles, the authors concluded that females are at greater risk of ACL injury during the preovulatory phase of the menstrual cycle due to a variety of factors, including increased joint laxity. Balachandar et al., (2017) differed from the review of Zazulak et al., (2006) in that Balachandar and colleagues reported the main window of risk was earlier in the menstrual cycle compared to the findings of Zazulak et al., (2006) (preovulatory vs. ovulatory phase) (Abt et al., 2007). Sarwar et al., (1996) found that females experience changes in muscular strength, relaxation and resistance to fatigue in human muscle during the menstrual cycle. However, in a sample of only 20 participants, the authors relied on estimations of the menstrual cycle phases, the validity of which has been more recently questioned by researchers (Vescovi, 2011).

Although the systematic reviews from Balachandar et al., (2017) and Hewett et al. (2007) concluded that the pooled research suggested increased injury risk during the preovulatory phase of the menstrual cycle, these conclusions are not without caution. Firstly, it is noted that due to the scarcity of research in this area when written, only seven studies were included in Hewett and colleague's (2007) systematic review. The authors point out that sufficient statistical power was

unable to be calculated due to low overall participant numbers. Other researchers (Abt et al., 2007; Hertel et al., 2006) did not present conclusions supporting the work of Hewett et al., (2007), again due to experimental flaws. Hertel et al., (2006) investigated the effects of the menstrual cycle on hamstring and quadriceps muscle strength, knee joint position sense, postural control, and knee joint laxity, finding no changes across the course of the menstrual cycle. Although their study also suffered from low participant numbers (n = 14), compounded by the exclusion of six participants during the study as they did not ovulate in the second month of testing, the authors noted inconsistencies in the concentrations of progesterone and oestrogen (assessed by way of urinalysis) making drawing conclusions based on hormone concentrations problematic. The study of Hertel et al., (2006) highlights the challenges of researching the effect of the menstrual cycle on injury. Many studies investigating the effects of the menstrual cycle on injury use participant completed questionnaires to determine the specific period of the menstrual cycle when injury occurred (Martin et al., 2021; Vescovi, 2011). Vescovi (2011) points to research which found significant variability in the cycles of women (between the ages of 18 and 44) of between 7-14 days in nearly 50% of women, with 20% of women experiencing cycle-to-cycle variability of more than 14 days (Creinin et al., 2004; Fehring et al., 2006). These occurrences make accurate prediction of specific cycle phases via self-reported questionnaires problematic. Moreover, even biological sampling at one specific point in time would limit the ability to identify which phase of the menstrual cycle the woman is currently in (Vescovi, 2011). For example, Vescovi (2011) states that only if injury occurred in the first five days of menses can researchers confidently predict that the woman is in the follicular cycle phase. Herzberg and colleagues (2017) conducted a more recent systematic review investigating the effects of the menstrual cycle and contraceptives on ACL injuries. Despite a significant increase in publications since the work of Hewett et al., (2006), Herzberg (2017) ranked the overall quality of these publications as "very low", and, in agreement with Vescovi (2011), cited the complexity in the accurate assessment of the menstrual cycle phase as an erroneous variable.

Overall, there is theoretical and evidence-led research pointing to the influence of the menstrual cycle on the incidence of injury. However, it is difficult to draw firm conclusions from current research due to its lack of quality in terms of participant numbers and the challenges of accurately identifying the specific phase of the menstrual cycle of when injury took place. Moreover, most research is focused on sports other than football, or on professional football players, meaning it is difficult to generalise these conclusions for grassroots participants.

2.2.6.3 Neuromuscular contributors

The term neuromuscular control refers to "unconscious activation of the dynamic restraints surrounding a joint in response to sensory stimuli" (Alentorn-Geli et al., 2009, p. 713). In the context of injury risk, a variety of neuromuscular risk factors include patterns of muscular recruitment, relative muscular strength, joint stability and stiffness and resistance to fatigue.

2.2.6.3.1 Neuromuscular recruitment and relative strength

Adolescent females demonstrate a variety of neuromuscular imbalances, particularly quadricep dominance and leg differences dominance (leg-to-leg differences) (Quatman et al., 2006). Testing sub-elite female footballers, (Mills et al., 2015) found that muscular imbalances would affect the neuromuscular activation of other co-contracting muscles. Specifically, they found issues with the hip flexor muscles resulting in lower activation of the gluteus maximus, yet greater hamstring coactivation. This reduction in gluteus maximus-to-hamstring ratio would affect lower-limb biomechanics potentially leading to increased injury risk, with strategies for maintaining optimal hip flexor muscle length potentially a protective strategy for lower-limb injury prevention (Mills et al., 2015).

H/Q_r is the often-cited muscular imbalance issue responsible for injury, especially to the knee. Often termed 'quadricep dominance', the comparatively weak hamstring group are unable to prevent quadriceps-induced anterior tibial shear forces (Davidson & McLean, 2016; De Ste Croix et al., 2018). Davidson and McLean (2016) suggest a contributing factor to knee injury during maturation is an increase in quadricep dominance coupled with a comparative weakening in the ACL ligament, reducing the ACL's ability to stabilise the joint between early and mid-maturation. The authors note however, that precise evaluation of *in-vivo* ACL integrity is challenging. Furthermore, during maturation quadricep muscle strength increases relative to body mass (Hopper et al., 2017). Coupled with a plateau of the knee flexor (hamstring muscles) strength relative to body mass, this further exaggerates the imbalance in H/Q_r, increasing injury potential (Hopper et al., 2017).

H/Q_r increases as the knee approaches full extension (0°-40°). As the eccentric contraction of the hamstring group is less effective near full extension of the knee, the hamstring reduces the ability to withstand anterior tibial forces created by the contracting quadriceps, increasing the likelihood of traumatic injury in footballers (El-Ashker et al., 2017; Read et al., 2018; Söderman et al., 2001). Interestingly, female footballers have increased levels of quadriceps activation and decreased hamstring activation, increasing injury risk compared to male participants (Myer et al. 2009; Chappell et al., 2007). Moreover, Padua et al., (2005) found increased quadriceps and soleus activation during hopping as well as a decreased H/Q_r in women compared to men. De Ste Croix et al., (2017) reports that co-contraction of the gastrocnemius and quadriceps muscles increased strain on the ACL. Whilst noting that the soleus does not cross the knee joint, the effect that increased soleus activation may have on the ACL could be investigated further. A reduction in H/Q_r may, in part, be due to contributing factors of hip position during higher velocity-movements, suggesting that the positions used during isokinetic testing may have altered muscular length-tension relationships in their participants (El-Ashker et al., 2017). Moreover, El-Ashker et

al., (2017) questions the ecological validity of isokinetic testing used to calculate reciprocal H/Q_r. Additionally, the ages of the female participants (mean age = 29 years) means that these studies may not be generalisable for adolescent females. However, as H/Q_r remains relatively stable during maturation (Myer et al., 2009), confidence can be assumed in the results of El-Ashker et al., (2017).

Greater knee valgus is a predictor of higher injury risk (Mayer et al., 2009). Read et al., (2018) finds that greater knee valgus moments appear in elite male adolescent footballers around the age of 13, potentially due to increased limb dominance. A conclusion could be made therefore, that limb dominance is a predictor of lower-limb injury risk. Yet in a longitudinal study with over 300 participants, there was no correlation between limb dominance and ACL injury rates (Negrete et al., 2007). Of note however, the researchers found increased incidence of females injuring their left leg in particular. The authors conclude that further research is needed to ascertain any neuromuscular asymmetry between right and left lower limbs in females.

2.2.6.3.2 Joint stiffness and joint stability

Joint stiffness relates to the ability of the muscles to increase joint stability that protects the joint's ligaments from damage when under load (Alentorn-Geli et al., 2009; Ford et al., 2010). Adolescent females have significantly reduced joint stiffness compared to adolescent males (Ford et al., 2010) as males active lower-limb muscles (gluteus muscles and gastrocnemius) earlier and for longer than females (Kibler & Livingston, 2001). This leads to a hypothesis that joint stiffness is required for injury-free participation. Females demonstrate increased joint stiffness as they progress through biological maturation with more pronounced reductions in leg stiffness (at the ankle, knee, and hip) in female footballers ages under 12 years of age (Ford et al., 2010) which normalisers by the age of 14-15 years old (De Ste Croix et al., 2017). Of note, Ford et al., (2010) demonstrated that the neuromuscular strategy that females use to increase joint stiffness was in part due to a

quadriceps-dominant recruitment pattern, a recruitment pattern that has been suggested to heighten injury risk at the knee (Davidson & McLean, 2016).

In their study, Ford et al., (2010) found that joint stiffness of the ankle and hip joint increased during maturation in males, but not females. This suggests that joint stiffness may not be a naturally occurring trait in female footballers. However, this conclusion may be joint-specific as the same authors reported that both males and females increased knee joint stiffness over the same time frame. Absent from the report of Ford et al., (2010) is the sporting level of their participants, and thus correlations cannot be made between playing level and changes in joint stiffness throughout maturation.

2.2.6.3.3 Fatigue

Injury rates increase during the latter stages of competitive matches in male professional football, a finding that could lead to questions as to whether these injuries are fatigue-induced (Ekstrand et al., 2011). In professional female players, game-induced fatigue results in a reduction in high-intensity activity towards the end of the game (Krustrup et al., 2010). Furthermore, this reduction in high-speed activity is not mirrored in non-footballing activities (i.e. isolated explosive jumps), suggesting that these fatigue mechanisms are specific to in-game play (Krustrup et al., 2010**)**. Moreover, the effects of fatigue on lower-limb neuromuscular control of elite adolescent female footballers are more profound around the time of PHV (De Ste Croix et al., 2018a). In their study, De Ste Croix et al., (2018a) used the 90-minute soccer-specific aerobic field test (SAFT) to replicate in-game demands, thereby accounting for the methodological findings of Krustrup et al., (2010). Increases in hamstring fatigue would reduce the hamstring's ability to counteract the forces of motion and the quadriceps muscle, thereby allowing anterior posterior tibial movement to a degree that may cause knee injury (Mills et al., 2015). De Ste Croix et al., (2018) theorises that increased fatigue-resistance during maturation maybe one mechanism that helps reduce injury incidence as

female footballers age. Reduced knee joint stiffness has already been linked to increased injury rates. Fatigue-associated reductions in leg stiffness are connected to age - participants demonstrated a greater degree of leg stiffness around the time of PHV (12-13 years old) whereas older adolescents (U15s) were able to maintain lower-limb stiffness post fatigue protocol (De Ste Croix et al., 2017; 2018). In contrast, these results differ from later work that found neither neuromuscular control or leg stiffness was compromised in male players following competitive match play (De Ste Croix et al., 2019). Although the authors are keen to point out that there appears to be a very individualised response to fatigue in adolescent footballers, the divergence of the development of joint stiffness between male and female adolescent footballers is a potential area for further investigation. Future research could also control against differing fatigue protocols used in both studies (SAFT vs match-play).

Elite female footballers demonstrate increased gastrocnemius activity during unanticipated football-specific movements (Landry et al., 2007). Co-contraction of the gastrocnemius and quadriceps muscle increased strain on the ACL, and thus fatigue in these muscles may influence injury incidence, especially for players in the early stages of maturation (De Ste Croix et al., 2017). Researchers have investigated the association between hamstring fatigue and transverse plane knee control (Nyland et al., 1999) and sagittal plane movements (Wojtys et al., 1996). Nyland et al. (1999) reported that fatigue induced by eccentric workload decreased transverse plane knee control during cross-over cutting activities. Additionally, Wojtys et al., (1996) observed increased anterior tibial translation in fatigued participants with no prior knee injury. Whilst these studies had limited sample sizes (20 and 10 participants respectively) and were not conducted on footballers in footballing situations (and thus may not fully be generalisable to the footballing populations), it adds further weight to the assertions of De Ste Croix et al., (2017; 2018a; 2019) that fatigue, in part, could be linked to increased injury rate.

2.2.6.4 Biomechanical factors

2.2.6.4.1 The sagittal plane

DiStefano et al., (2015) found that there are differences in landing kinematics when comparing males and female adolescent athletes. Specifically, females landed with reduce sagittal plane motion (flexion) at the hip and knee joints during contact with the ground, with females landing in a more upright position compared to males (DiStefano et al., 2015). This is potentially as the result of a reduction in the relative strength of the quadricep muscles during maturation (DiStefano et al., 2015) and is shown to increase injury risk (Hewett, 2000). Yu et al., (2006) maintains that dynamic angular impact velocity rather than absolute joint angles upon impact is a greater injury risk factor. The authors state that a more upright position upon landing resulted in a greater ground reaction force as the ability to absorb the impact forces in such body positions decreases. Having large degrees of flexion upon impact did not reduce injury risk unless the joints were active/dynamic (moving) at the point of impact (Yu et al., 2006). Further supporting the view that the ability to absorb ground reaction force is more important than the angle of the knee at impact, Hewett et al., (2005) found no differences between knee flexion angles at initial contact on injured vs. uninjured adolescent female athletes.

2.2.6.4.2 The frontal plane

Most of the literature regarding the biomechanical influence on lower-limb injury focuses on lateral movement, specifically valgus movement at the knee joint. Knee valgus moments are comprised of knee abduction, hip adduction and internal rotation (Fox et al., 2017). Dynamic valgus moments upon impact have long been linked to increased injury risk (Hewett et al., 2005). Females demonstrate knee valgus moments five times greater than males (Sigward et al., 2012). Supporting the research on H/Q_r, females exhibited higher knee valgus moments at the knee due to increased reliance on the quadricep muscles (as opposed to the gluteus muscles) during deceleration actions

(Pollard et al., 2010). Although measuring a drop-jump task as opposed to in-game football analysis, Pollard and co-workers (2010) found that the greater knee valgus angles resulted in a reduction in ground-reaction force absorption by the gluteal muscles. The knee joint therefore absorbed greater levels of impact forces, increasing injury risk potential. However, Nilstad et al., (2014) did not find that higher knee valgus angles measured on a drop-jump task correlated with increased knee injury risk but did link to increased ankle injury risk. The authors theorised that the discrepancy in their research compared to other literature maybe because of using a football only cohort, and that as a result the elite players used in their study may have developed increased frontal plane neuromuscular control. Indeed, Le Gall et al., (2008) hypothesises that injury rates in younger players maybe due, in part, to reduced technical and tactical ability. It is reasonable to suggest that this increased neuromuscular control in the frontal plane may be absent in grassroots participants.

Whilst trunk strength has not been shown to correlate to performance level in elite adult female footballers (Nesser et al., 2008), the ability of the 'core' to control lateral movement has also been purported to be an important injury risk modifier, with lateral trunk movement one predictor of lower-limb injury in females, but not males (Zazulak et al., 2007). Of note however, the participants in Zazulak and co-worker's study were in their late teens (mean age = 19.4 years old). At this age injury risk is consistent with adult female footballers (Hägglund & Waldén, 2015; Faude et al., 2013) and thus the impact of lateral trunk movement on adolescent grassroots female footballers cannot be assumed.

In addition to lateral trunk motion, elite adult female players with higher ankle motion (foot pronation) were 23% more likely to suffer a lower-limb injury (Nilstad et al., 2014). However, once analysed by way of multivariate analysis, these risk factors were not supported (Nilstad et al., 2014). Although there is a dearth of literature investigating ankle motion and injury risk on adolescent

female footballers, elite female footballers had increased ankle eversion angles compared to men (Landry et al., 2007). Increased ankle eversion angles have been linked to dysfunctional lower-limb kinematics increasing knee valgus stress or anterior tibial translation, actions that have already been linked to increased lower-limb injury risk (Alentorn-Geli et al., 2009).

Overall, the biomechanical causes of lower-limb injury in female footballers are mainly focused on knee valgus moments. As previously suggested, it would be erroneous to consider a singular cause such as a biomechanical cause in isolation, as evidenced in the univariate versus multivariate analysis of Nilstad et al., (2014).

2.2.7 Measuring maturation

Authors have cited numerous reasons as for the need to measure maturational development in youth participants. Identifying and monitoring maturational timing and tempo will help identify when the participants would be at higher risk of injury so that preventative neuromuscular training can be implemented (Quatman et al., 2006). Monitoring maturational development also allows researchers to differentiate whether natural maturational development or exercise training alone is responsible for any change in exercise performance or injury incidence (Lloyd et al., 2014). Chronological age used as a metric in the assessment of growth or maturation has been criticised due to its inability to measure individual differences in timing (onset) and tempo of biological maturation in individuals (Mirwald et al., 2002). For example, in females, differences between biological maturational age and chronological age can differ by up to four years (Malina, 2014). Although it is not in the scope of this literature review to fully critically analyse measures of maturation used within injury risk research, it is pertinent to give and overview of the complexities, ethical dilemmas and contrasting views on maturation measurements.

The 'gold standard' method of assessing biological maturation is via radiological skeletal age assessment. These assessments raise ethical concerns, not only for cost implications for researchers, but also for requiring adolescent participants to have an increased exposure to x-rays (Lloyd et al., 2014). A non-radiological 'gold standard' measure of maturation also includes the Tanner scale of direct evaluation of secondary sex characteristics (Sigward et al., 2012). As this assessment is a physician-led assessment, there are questions as to the ethical nature of using the Tanner scale at a time of increased physiological and psychological change for the child (Malina, 2014). Moreover, Lloyd et al., (2014) reports that there can be a lack of correlation between Tanner stage 1 (prepubertal – lack of breasts, testes, or pubic hair) and skeletal age (via radiological assessment) of over four years or more. The Tanner scale also fails to assess the time period that an individual is in a particular stage (stages 1-5) or when the stage may have started and thus fails to assess the tempo of maturation (Malina, 2014; Lloyd et al., 2014). Additionally, the Tanner Scale is unable to be used outside of the pubertal phase of growth and maturation in children (Lloyd et al., 2014). The modified Pubertal Maturational Observational Scale (PMOS) has been used and verified against the Tanner Scale (Quatman et al., 2006) yet suffers from similar ethical issues due to the observational need of maturation assessment. Some researchers have also used onset of menarche as a measure of maturation; however, onset of menarche is a late maturational event occurring after peak height velocity which would therefore not be of use in many maturational studies and would limit participants from the female sex (Malina, 2014).

Many researchers highlight that injury incidents in female adolescent participants accelerate around the time of peak height velocity (PHV) or age at PHV (APHV) (De Ste Croix et al., 2018; De Ste Croix et al., 2018a). PHV is defined as the maximum rate of growth during the adolescent gross spirt (Lloyd et al., 2014) and has been suggested to be an "excellent indicator of maturity timing" (Malina, 2014, p. 160). One benefit of PHV (over the Tanner scale, for example) is that it can

predict PHV even in children as young as 11 years for males and nine years for females (Mills et al., 2017).

There are questions around the utility of PHV/APHV used to assess maturational progress at a specific isolated moment in time (Mirwald et al., 2002; Moore et al., 2015). For example, Lloyd et al., (2014) points out a flaw in the use of PHV such as if a coach starts working with young participants at the age of 14 without being in possession of previous growth data. As a result, Mirwald et al., (2002) created a one-time, non-invasive and practical anthropometric method to assess maturity status during adolescence, finding that age from PHV can be accurately predicted by measuring the differential timings of growth in height, sitting height and leg length. However, Moore et al., (2015) reports data from longitudinal studies that found that APHV was underestimated in gymnastics with a later observed APHV, yet overestimated in the same cohort with an earlier observed APHV.

In their systematic review of methodological approaches for predicting PHV in adolescents, Mills et al., (2017) concludes that radiological investigations are still the gold standard method of measuring maturation. The authors found improved accuracy when estimating PHV if multiple measures are taken over a period. Mills et al., (2017) highlights that foot length and sub-ischial leg length based PHV estimation to be a potential for further investigation due to its ease of use, though more studies confirming its validity and reliability are needed. PHV should be measured annually for improved accuracy (Mills et al., 2017), however, this is not constantly reported in literature.

2.2.8 Section summary

Previous research demonstrates an increased injury risk for adolescent female footballers, an injury risk that may be substantially underestimated (Clausen et al., 2014, p.6). A variety of factors have been identified that increase injury risk in adolescent female footballers such as anatomical, hormonal, neuromuscular and biomechanical factors. Specifically, muscular fatigue, increased knee valgus moments and higher H/Q_r, as well as higher levels of generalised joint laxity have all been shown to increase lower-limb injury risk. The influence of hormonal development or the role of flexibility are suggestive of increased injury risk, but more high-quality research in these areas is required for more definitive conclusions to be drawn. The influence of the Q-Angle on injury risk has generally not been supported. Other injury risk areas such as increased BMI may only be identified as an injury risk indicator if considered alongside other co-contributing injury risk indicators. It is likely that one single factor is not solely responsible for an increase in injury risk or rates (von Rosen et al., 2017). For example, Meeuwisse et al., (2007) outlines a scenario where a variety of risk factors interact to heighten injury risk potential. In their analogy, Meeuwisse et al., (2007) highlights how fatigue could alter neuromuscular control, if the participant had previous injury, reduced recovery periods and participate in higher risk environments where they perform high risk biomechanical manoeuvres (pivoting under deceleration load), all these factors together will combine to significantly increase injury risk.

During puberty, males develop natural increases in strength, power and coordination. This 'neuromuscular spurt' correlates to increasing chronologic age and maturational stage yet is generally absent in pubescent females (Quatman et al., 2006; Hopper et al., 2017). The absence of a neuromuscular spurt results in an increase in joint instability, dominant-to-nondominant leg differences and H/Q_r actions for adolescent females (Quatman et al., 2006), all of which have been previously linked to increased injury risk. The absence of the neuromuscular spurt in females has been attributed to hormonal fluctuations after the onset of puberty (Hewett et al., 2007). However,

despite the natural absence of a neuromuscular spurt in adolescent females, many researchers suggest that it can be developed by targeted neuromuscular training (Quatman et al., 2006), particularly around the stages of Tanner 1 and Tanner 2 (Myer et al., 2011) helping to reduce the sex-related disparity in neuromuscular activation, force absorption, active joint stabilisation, muscular imbalances and dynamic biomechanics (Myer et al., 2008). From a methodological point-of-view, there is debate among researchers as to the most accurate and ethical method to measure maturation, with PHV being used most often. However, it is not always evidenced in research as to the number of measurements taken to estimate PHV, as one may not be enough to ensure accuracy.

There is an over-focus on injury risk factors affecting the ACL in females. However, this is due to the significant abundance of literature in this specific area coupled with a dearth of literature focusing on other lower-limb injuries as knee injuries are the most prevalent time-loss injuries in female football. Additionally, the significant disparity between ACL injuries in males and females, coupled with the serious acute and chronic consequences of this injury means that this area has seen increased research focus. Emery (2003, p. 256) states that "sports injuries in children and adolescents may be predictable and potentially preventable by up to 50%" (Myer et al., 2011). It is therefore not surprising that many researchers (Davidson & McLean, 2016; Myer et al., 2008; Read et al., 2018; Fox et al., 2017; Price, 2004) have suggested that screening to identify participants at a higher risk of injury should be further researched and implemented. A variety of neuromuscular lower-limb screening tools and their application to grassroots female footballers will be discussed in the next section.

2.3 Neuromuscular screening tools

Neuromuscular refers to the relationship between nerves and muscles. It encompasses the complex interplay of signals transmitted from the nervous system to the muscles, ultimately controlling movement and function (Purves et al., 2004). As a result, within a physical activity and sport setting, a NST examines this interaction related to muscular strength and power, balance and coordination, flexibility and mobility, and postural control, among others (Cejudo et al., 2015; Chalmers et al., 2017; Cook et al., 2014; Fältström et al., 2021; Fort-Vanmeerhaeghe et al., 2017). Typically, a performer will undertake a movement or action which is then assessed and graded by an assessor (Rogers et al., 2019). Read's (2016) doctoral thesis on predicting lower extremity injury in male adolescent footballers mentioned the term "neuromuscular screen" sparingly, despite outlining 15 screens fitting the above definition. The term 'neuromuscular screen' is broad and rarely used in research, as seen in SPORTDiscus searches, where 'neuromuscular movement screen' yields no results, yet a type of NST, the 'Functional Movement Screen' returns over 400. This highlights challenges with naming conventions and screening methods (Hegedus et al., 2015). Instead, authors typically label their research according to the specific screening tool used, such as the Functional Movement Screen or Tuck Jump Assessment. This approach makes it difficult to gain a comprehensive understanding of how these tools are utilised within the industry, particularly regarding their prevalence and intended applications (see Chapter 3). Many researchers have NSTs tailored to specific populations or sports contexts, particularly with the aim of predicting injury risk. These NSTs will be discussed in the following section. To assess the validity of a given NST, however, it is essential to clarify its ability to predict injury - assuming that is the intended purpose. The question of whether NSTs can accurately predict injury is a complex issue, involving philosophical considerations, which will be briefly outlined below.

2.3.1 "Predicting" injury

Chapter 2, section 2 discussed a variety of mechanisms of injury that may potentially lead to a participant being identified at a higher risk of injury. In their paper titled 'Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: a prospective study', Hewett et al., (2005) predicted ACL injuries with 78% sensitivity and 73% specificity in young female athletes using regression analysis. Moreover, Nilstad et al., (2014) reports that excessive knee valgus angles increased ankle injury by 36% in elite female footballers, whereas footballers who overpronated were at a 23% higher risk a sustaining a lower-limb injury. In their study with military recruits, Uhorchak et al., (2003) found that a narrowed femoral notch width, increased BMI, generalised joint laxity and increased anterior/posterior tibiofemoral translation was able to predict 75% of ACL injuries in women. Analysis of trunk displacement and trunk proprioception coupled with a history of back pain was able to predict ligament injury in female athletes with between 84-91% accuracy (Zazulak et al., 2007).

As noted, (Chapter 2: section 2) severe lower-limb injury is a relatively rare occurrence. The studies of Hewett et al., (2005) and Zazulak et al., (2007) calculated their prediction regression models based on only nine and 11 injuries from cohort sizes of 205 and 277 respectively. Moreover, in the work of Uhorchak et al., (2003) it is unclear as to which injury risk factor was more predictive of injury risk compared to the others. It was consistently reported in Chapter 2: section 2 that lower-limb injury occurred not because of a sole risk factor, but due to a variety of both intrinsic (anatomical, hormonal, biomechanical and neuromuscular) and extrinsic (environment, equipment etc.) risk factors. Collectively therefore, the ability to generalise the findings of these authors are questionable. It is outside the remit of this dissertation to fully explore the philosophical perspective of whether injury can indeed be 'predicted' by any means. However, the importance of this debate cannot be overlooked, and thus will be discussed, in brief, below.

In previous work, Ronald Bahr has outlined screens attempting to predict injury. For example, screening in Engebretsen and colleague's research could not "predict" an increased risk of new knee injuries in professional Norwegian male footballers (Engebretsen et al., 2011). Although Engebretsen and co-workers were unable to accept their hypothesis, the attempt to "predict" the outcome (injury) based on screens suggest, like Hewett et al., (2005) and Zazulak et al., (2007), that injury can indeed be 'predicted'. Yet despite his previous work, in 2016, Bahr stated that "screening tests to predict injury do not work - and probably never will" (Bahr, 2016, p. 1). Bahr discusses the inherent validity issues with regards to the prediction of injury via injury screening, outlining three steps needed to validate such screen(s).

1. Prospective study to establish screening cut-off values
2. Validation study of cut-off values using multiple cohorts
3. Randomised control trial to test the combined screening and intervention programme

Bahr (2016) concludes by suggesting that no research currently exists abiding by the methodical rigour of his recommendations.

However, there are clear deviations between the views of Bahr (2016) and the proposed research here within. Firstly, a distinction needs to be made between 'prediction' and 'risk factors'. The research produced in this dissertation aims to, in part, help identify those female adolescent football players who may be of greater risk of injury, based on a variety of neuromuscular screens. It will not aim to quantify such risk as to make an absolute prediction ("they will get injured", "they have a 75% of chance of injury"). Bahr (2016) states how injury prediction screens require "cut-offs" where one participant "below the line" will not have a greater risk of injury, whereas another participant with a score "above the line" will be at greater risk of injury. However, a neuromuscular screen could be viewed as a continuum, and any neuromuscular dysfunction identified because of the screen(s) will assist the coach (or similar) in developing appropriate training recommendations

to improve AMC and, indirectly, potentially reduce injury risk. As an analogy, it is recognised that obesity is the primary cause of osteoarthritis in the knee joint (Anandacoomarasamy et al., 2008). However, not all individuals who are classified obese will develop osteoarthritis at the knee joint. Conversely, individuals who are not classified as obese may still develop knee osteoarthritis. Similarly, not all participants identified as 'higher-risk' as a result of the screens used in this thesis will eventually suffer an injury to the lower-limb, nor is this research intending to promote such views. In their reply to Bahr's commentary, Hewett, (2016) concedes that injury 'prediction' is a nuanced term, but that screening can be used to categorise participants into subgroups.

In addition to the debate on injury 'prediction', ethical considerations need to be discussed. If, for example, a player completes a neuromuscular screen and is categorised in a subgroup labelled "higher-risk", what effect might that have on the participant? Might they want to withdraw from participation due to fear of injury? Would they perform actions differently as a result (i.e. try and reduce player-to-player contact)? Would this affect their enjoyment of the game, the desire of the coach to play the participant or for their parents or guardians to want their child to continue playing? Moreover, as previously noted in Chapter 2: section 1, grassroots coaches have limited medical support, are not medically trained, nor are likely to be a qualified strength and conditioning coach. Should it be their remit to conduct neuromuscular screens and potentially advise on resulting exercise programming? Yet, if a coach is aware of a player with dysfunctional neuromuscular movement (via simple observation of a player's movement patterns), is it ethical that a coach does nothing?

Ultimately, it is the views of the author that due to the variety of intrinsic and extrinsic factors, injury cannot be predicted based upon neuromuscular screens. However, certain neuromuscular movement patterns increase injury risk for participants, and thus, if coaches have the skills, knowledge and tools available to them, as the individual ultimately responsible for the child

performer, they have a duty to attempt to improve the safety of participation (Micheli et al., 2000). This is the goal of this dissertation; to develop a neuromuscular screening tool that grassroots coaches of adolescent female footballers can confidently, consistently and correctly use to identify performers who "require additional neuromuscular training", with the ability to accurately 'predict' injury not being considered when selecting the most appropriate screens.

2.3.2 Testing batteries for athletic movement competency

This section will explore a variety of related NSTs that make up a testing battery. Whilst the focus of this dissertation is on the development of a lower-limb NST battery, some of the screens analysed below will include upper body movements. This is relevant, as previous research (Zazulak et al., 2007) suggests upper body movement (lateral trunk movement) is a potential injury risk factor.

2.3.2.1 The Functional Movement Screen™

The Functional Movement Screen™ (FMS) is a battery of seven movements and 16 scoring screens assessing stability and mobility, descending proximally to distally, designed to identify functional movement deficits and asymmetries (Chimera & Warren, 2016; Teyhen et al., 2012).

The FMS has been found to provide an "adequate level of reliability" when used by novice raters to assess healthy members of the armed forces, with only one screen (in-line lunge) showing less than excellent or substantial interrater agreement (Teyhen et al., 2012, p. 534). Moreover, the FMS also demonstrated excellent interrater agreement when comparing two novice and two expert raters when assessing a videotaped participant (Minick et al., 2010). Of note, the participants (23 females and 17 males) in Minick et al., (2010) had a mean age of 20.8 years, so were all outside the maturational development window.

The FMS has also shown to have high reliability of both real-time intersession and interrater screens, except for the hip screen component (Onate et al., 2012). The authors postulated that the lack of reliability of the hip screen could be due to the dynamic nature of this screen. The study of Onate et al., (2012) only used two raters. To address this limitation, Leeder et al., (2016) reported high interrater reliability for the FMS with 20 physiotherapist raters, and found no link between reliability and clinical experience, suggesting potential use of the FMS by novice coaches (Leeder et al., 2016).

The creators of the FMS state that the FMS score was not designed to be used as an assessment or evaluation tool to predict injury (Cook et al., 2014a, p. 558). However, Chorba et al., (2010) correlated a total FMS score of less than 14 as a cut-off to determine increased injury risk in professional male American football players and female collegiate athletes respectively (Kiesel et al., 2007; Chorba et al., 2010). Yet, notwithstanding the earlier discussion regarding the use of cut-off values, Teyhen et al., (2012) and Kazman et al., (2014) disagrees with the cut-off value reported and tested by Kiesel et al., (2007) and Chorba et al., (2010), mainly due to the scoring system used in the FMS. One reason for this is the limited total composite scores possible, where 96% of the individual screens completed scored a 2 or 3. Authors hypothesise that it may be more beneficial for participants to focus on actions receiving lower scores than to ignore them if achieving a composite score of >14 (Kazman et al., 2014). Moreover, it is noted that even the creators of the FMS state that scoring a 3 on screens is challenging (Schneiders et al., 2011), further reducing the spread of composite scores. As a result of all the above, cut-off scores of 14 cannot be generalised to adolescent, grassroots participants (Schneiders et al., 2011) with researchers suggesting a 100-point scoring system be implemented to improve sensitivity (Kazman et al., 2014).

2.3.2.1.1 The FMS for use in grassroots football

Despite the ease of use in a group setting, lack of required equipment and the apparent reliability of the FMS (Teyhen et al., 2012), the utility of using the FMS on football-specific populations and/or youth performers in general has been questioned. Firstly, the FMS does not assess sport-specific movements such as change of direction, an action already documented to be causal of injury. Secondly, the FMS does not assess how participants perform during competition or under load (Cook et al., 2014). Thirdly, Lephart et al., (1997) and McMullen and Uhl (2000) find that in adolescent individuals, average composite FMS scores are only just above the 'cut-off' threshold of 14 (14.14 ± 2.85 and 15.7 ± 1.9 points respectively). Therefore, most adolescent performers are already close to the cut-off, suggesting preventative measures via neuromuscular training should already be utilised, thus calling into question the need to complete the FMS in the first place (if only considering the final composite score and not the score of the individual screens). Working with a population of 360 adolescent footballers (mean age 16.6 ± 0.8 years), Chalmers et al., (2017) concluded that the FMS was "somewhat" useful for use with the population, specifically due to the ability to assess asymmetrical movement, which has been linked to increased injury risk. Like many before them, Chalmers et al., (2017) purported the benefits of using individual screens within the FMS for assessment and exercise prescription over the use of the composite score, finding that the <14 cut-off was again not supported in their study. Portas et al., (2016) conducted a cross-sectional observational study on 1163 adolescent boys (aged 8-18 years). The authors found that as participants moved through maturation, their ability to achieve a satisfactory score of the sections of the FMS (total score, screens related to movement, screens related to stability) increased. The authors suggest that natural developments in the nervous system may account for this improvement, and they therefore conclude that using the FMS for younger age groups (around the time of PHV) may lead to erroneous results. Additionally, the authors find that nearly 75% of players achieved a score of <14, meaning that, as postulated above (using data from Cook et al., 2014a), most participants would already require additional neuromuscular training as the FMS

could not differentiate between good and poor movement in this population. Whilst the study of Portas et al., (2016) was conducted on male and not female footballers, it is argued that these results could be generalised to the female populous. As mentioned in Chapter 2: section 2, the neuromuscular spurt is absent in maturing females. This suggest that female scores would be as low, if not lower, than the scores reported by Portas et al., (2016), reinforcing the notion that the FMS would be unable to discriminate between good and poor movement.

In conclusion, the FMS has been shown to be a reliable screen. Its utility for grassroots football is increased due to its ease of use for novice users, requiring limited equipment. However, its use for screening youth sporting participants (especially adolescent females) undertaking dynamic activities such as cutting movements, has not been confirmed. Its decreased sensitivity and ability to differentiate between good and poor movement in adolescent performers would reduce its value as a screening or prescription tool, and thus would not be recommended for use on adolescent female footballers.

2.3.2.2 Other whole-body screens

Whilst most literature discussed in this dissertation relates to the ability of a NST to discriminate injury risk stratification or assess performance (i.e. sprint times), the ability of a NST to assess the fundamental movement patterns that form the foundation for further resistance-based exercise (AMC) must also be recognised (Garrett et al., 2018). These movement dysfunctions may limit performance, hinder progression and ultimately increase injury risk (Garrett et al., 2017).

Although the FMS has seen significant research, there are other less well-known screens that require discussion. One of these screens is the Athletic Ability Assessment (AAA) (McKeown et al., 2014). As suggested above, McKeown and co-workers argued that the popular FMS has poor ecological validity as it does not reflect the demands of complex dynamic athletic movements, with

the limited scoring scales resulting in participants receiving the same score despite completing the screen in different ways (Rogers et al., 2019). The AAA may therefore be more applicable to dynamic sports such as football.

Rogers et al., (2021) found that using the 6-point scoring scale in the AAA allowed raters to discriminate movement patterns more specifically, which would allow for more individualised exercise prescription. However, questions remain regarding the reliability of the AAA. Although studies report "near perfect" interrater reliability when conducted retrospectively via video recording, this was not reproduced during live assessments (Rogers et al., 2019, p. 133). Indeed, the authors of this study (which included the lead author who developed the AAA) caution users in the use of the AAA in real-time due to poor interrater agreement levels. However, they argue that the availability of video recording (using smartphones etc.), would allow most assessors the opportunity to record. Furthermore, they argue that this would reduce on-field assessment time, which would also be a benefit for participants.

Unfortunately, research into the AAA is limited (with nine articles on SPORTDiscus compared to over 400 for the FMS). There appears to be no research validating the AAA for footballers, or for female participants. Most research is related to Australian Rules football with an acceptance that participants improve their AMC to progress to more structured (resistance-based) strength and conditioning programmes. However, this goal may be outside of that of many adolescent female footballers who are playing at a grassroots level. Whilst Rogers et al., (2019) argue that video equipment is readily available, the requirement for volunteer coaches to spend additional time post-session analysing results may further reduce its usability in grassroots sport.

The Resistance Training Skills Battery (RTBS) is an alternative to the AAA, developed by Lubans et al., (2014). With its content validity determined by fourteen experts in youth resistance training,

the RTBS was shown to be able to detect changes in individual and composite resistant training competency scores in adolescent children (Lubans et al., 2014). Furthermore, the RTBS has been adapted and modified (RTBSc) for younger children (aged between 6 – 12 years old) and has also been shown to be a reliable tool for the assessment of AMC (Furzer et al., 2018). However, further research into the RTBSc has found that the screening tool was unable to differentiate muscular strength measures for participants and, as a result, the construct validity of the RTBSc has been questioned (Duncan et al., 2018). Moreover, although the RTBS has shown strong reliability for experience raters (Barnett et al., 2015), research into the reliability of the use of the RTBSc has not been established.

2.3.3 Screens of individual variables

While several full-body screening methods have been proposed for assessing athletes, footballers, and adolescents, numerous screening tools specifically target common injury mechanisms. As previously mentioned, lower-limb injuries are the most common in female football, with a significantly heightened risk of ACL injuries. Various researchers have identified several contributing factors to this increased risk, categorising them as quadriceps dominance, leg dominance, ligament dominance, and dynamic stability. To address these concerns, a range of screening tools has been developed to evaluate each of these perceived risk factors effectively.

2.3.3.1 Assessment of quadriceps dominance

Quadriceps dominance refers to the stabilisation of the knee joint via activation of the quadricep muscles, usually evidenced by reduced knee flexion during landing (Hewett et al., 2010). Quadriceps dominance has been suggested to be an injury mechanism for the knee, particularly among young female participants (Hewett et al., 2010).

2.3.3.1.1 Handheld dynamometer

2.3.3.1.1.1 Reliability of Handheld dynamometers

Although isokinetic dynamometry is considered the 'gold standard' measure in the assessment of lower limb strength testing (and by extension, the calculation of H/Qr), test protocols are often time consuming and expensive, making their widespread adoption limited (Mondin et al., 2018). As there is an association between hamstring strength and history of hamstring injury (Sconce et al., 2015), a more portable and cheaper assessment of hamstring strength, by way of Handheld dynamometry (HHD) has been recommended (Stark et al., 2011).

There is a lack of recent research into the use of HHD for strength assessments (Stark et al., 2011). Additionally, evidence of the reliability of HHD is lacking due to methodological disparities within research, such as lack of homogeneity in equipment used, the position of participant and assessor during testing and the force applied by the participant during testing (Stark et al., 2011). For example, the strong quadriceps muscles of adult male athletes would require a strong assessor to record reliable measurements, with inaccuracies of muscle strength being recorded when force exceeded 2000N (Stark et al., 2011; Thorborg et al., 2013). To reduce the force burden placed on the assessor during testing, the use of HHD with an external belt-fixation has been investigated, with interrater reliability reported to range between 0.76 to 0.95 (Thorborg et al., 2013). Further, HHD assessment of hamstring strength of injured participants has also shown to be reliable when the participant's hamstring is assessed at both short and long muscle lengths (Reurink et al., 2016).

Two of five studies comparing HHD measures to isokinetic dynamometry record an intraclass correlation coefficient (ICC) >0.75 (good), with three studies reporting ICCs of 0.55 to 0.81 (moderate to good), demonstrating acceptable reliability of HHD.

2.3.3.1.1.2 Use of HHD in grassroots football

There is a dearth of research investigating the use of HHD in grassroots football, especially female football. Only 3% (n = 2) and 17% (n = 6) of participants in the work of Reurink et al., (2016) and Thorborg et al., (2013) were female. All participants in both studies were also post adolescent (age range 18-60 years for Reurink et al., 2016 and mean age = 24.8 ± 3.3 years for Thorborg et al., 2013). Although the participants in Thorborg et al., (2013) were reported to be athletes, the type of sports these participants played was not documented.

The HHD could be seen as a valid test for use in grassroots youth football due to the relatively quick assessment protocol, coupled with the low equipment needs. Further equipment such as an external belt-fixation would potentially not be required to assess adolescent female footballers as their quadriceps muscles would potentially not exert a force >2000N. Low H/Qr has been linked to increased injury risk (Söderman et al., 2001). However, the position of the participant during 'gold standard' isokinetic dynamometry may alter muscular length-tension relationships (El-Ashker et al., 2017). Therefore, questions arise for the ecological validity of isokinetic testing (El-Ashker et al., 2017). The HHD test appears to offer a suitable, feasible and more ecologically valid test protocol for grassroots footballers.

2.3.3.1.2 Alternative field-based hamstring assessments

2.3.3.1.2.1 Reliability and use of the Nordic Hamstring Lower in grassroots football

The Nordic Hamstring Lower (NHL) has been presented as a reliable (ICC > 0.96) and ecologically valid assessment for footballers (Sconce et al., 2015). Using a cohort of post adolescent footballers (females = 9, mean age 24 ± 6 years), Sconce et al., (2015) reports that the break-point angle during the NHL is related to eccentric knee-flexor peak torque. The ability of the hamstrings to withstand eccentric loading is linked to reduced injury risk, thus validating the NHL for use by footballers (Sconce et al., 2015). In their study, Sconce et al., (2015) found that the NHL break-

point angle is related to eccentric knee-flexor peak torque. However, the researchers note that their work does not validate the use of NHL to predict hamstring injury risk (Sconce et al., 2015). Additionally, the authors note that the NHL does not replicate the hamstring's action during high-speed running for example, a time where most hamstring injuries are known to occur (Sconce et al., 2015). Indeed, a limitation of the NHL is the inability to assess movement speed (and other variables such as hip position) during assessment (Miralles-Iborra et al., 2023). However, the NHL has shown to associate with the gold standard isokinetic eccentric hamstring peak torque data (Miralles-Iborra et al., 2023). Therefore, despite a lack of literature investigating the NHL, given its ease of use and low cost of implementation, the NHL could feasibly be used within grassroots football (Sconce et al., 2015; Miralles-Iborra et al., 2023).

2.3.3.1.2.2 Reliability and use of Single Leg Bridge Test (SLBT) in grassroots football

The SLBT is designed to assess the strength endurance properties of the hamstrings (Freckleton et al., 2014). As this test is an exhaustive test, unlike the NHL, the test also assesses performance under fatigue and thus could be seen to be more football specific. Additionally, the position assumed during testing (where the foot is elevated on a box with the knee flexed) more closely replicates the terminal swing phase of running seen during football, where hamstring injuries are more likely to occur (Freckleton et al., 2014). In a study of 482 Australian Rules Footballers, Freckleton et al., (2014) reported the SLBT's ability to identify players at a greater risk of hamstring injury. Using a cohort of elite youth footballers, Mahnic et al., (2021) finds the SLBT can identify between-limb strength asymmetries, which have been linked to injury incidence rates (Hewett et al., 2010; Bishop et al., 2021). However, there was no difference in the number of repetitions performed by injured or uninjured limbs (Mahnič et al., 2021). The SLBT was shown to have good to excellent reproducibility (ICC 0.77 to 0.89) (Freckleton et al., 2014). It requires minimal equipment and is quick to administer to multiple participants at once (Mahnic et al., 2021; Freckleton et al., 2014). Footballers with reduced hamstring strength at the start of the season are

more likely to be injured (Mahnic et al., 2021). As a result, the SLBT has been recommended as a suitable field-based test to assess hamstring strength and between-limb asymmetries in youth footballers.

2.3.3.2 Assessment of leg dominance

Sports participants, especially those who specialise in a single sport early in life, often develop unequal side-to-side lower-limb dominance (DiCesare et al., 2019). In football, one leg is often planted on the ground whilst the other is used to perform kicking actions, or drive off for sprinting (Beese et al., 2015; DiCesare et al., 2019). In football, this asymmetry has been shown to be greater in female rather than male performers and has been linked to both increased injury incidence and reduced performance (Bishop et al., 2021; Hewett, et al., 2010).

A common way of measuring leg dominance asymmetry is via one-legged unilateral jump tests, with the Single leg countermovement jump (SLCMJ) and Single leg hop for distance (SLHD) (including both single hop and triple hop variants) being among the most popular in literature (Hegedus et al., 2015). They are generally considered to be ecologically valid and easy to implement for team sport participants (Beese et al., 2015).

2.3.3.2.1 Single leg hop for distance (SLHD) (including both single- and triple-hop variants)

2.3.3.2.1.1 Reliability of the SLHD

On reviewing 16 studies, the measurement error for the SLHD (triple hop) was reported to be fair (Hegedus et al., 2015). However, despite being the most researched screen, the reliability of the SLHD (single hop) is not known due to poor quality of evidence presented in research (Hegedus et al., 2015). For example, although Brosky et al., (1999) reported good to high intrarater reliability (ICC >0.80) of functional hop tests, the authors did not divulge the experience of the raters, and,

as such, the reliability of the SLHD conducted by experts compared to novice assessors cannot be ascertained. Additionally, although the SLHD was included as part of a new criterion-based instrument test for athletes with knee-injuries that was found to be reliable (Björklund et al., 2006), the protocol used was a 10-repeated hop jump test, which differs from most of the other available literature regarding the SLHD.

2.3.3.2.1.2 Use of the SLHD in grassroots football

The SLHD was designed as a horizontal alternative to vertical jump assessments. The argument for the development of horizontal NSTs centres around the increased ecological validity, in that many actions within football require horizontal as well as vertical movements (kicking, changing direction and landing after a header), with the SLHD replicating both (McCunn et al., 2017). However, whilst the validity of the SLHD has been discussed in literature, often the methodological approach in research has been questioned (Hegedus et al., 2015). These methodological questions extend to variants of the SLHD, such as the 6-meter timed hop and crossover hop for distance (Hegedus et al., 2015).

Whereas the SLCMJ has previously been linked to performance, this is not the same of the SLHD, with no correlations found between limb asymmetry and sprint performance (Bishop et al., 2021) or between SLHD and peak torque of the quadriceps and hamstrings (Barber-Westin et al., 2005). Moreover, there are suggestions that hop tests in general are unable to correlate with 'gold-standard' performance measures, such as strength assessments using isokinetic testing, for example (Hegedus et al., 2015). Whilst there is emerging evidence (Read et al., 2018; McCunn et al., 2018) of the ability of the SLHD to discriminate injury risk levels, there are questions regarding any cut-off values when reporting limb symmetry index (LSI) cut-off. For example, no correlation between female participants with a LSI <90% and knee injury was found by Fältström et al., (2021), thus raising questions regarding the use of LSI cut-off values used to identify increased injury risk.

However, the mean age of the participants in this study (20.2 ± 2.0 years) means that participants would not have been influenced by progression through maturation during the research period, and thus, the results of Fältström et al., (2021) may not be generalisable to adolescent populations.

Although there is a general scarcity of literature assessing adolescent female populations by way of SLHD test, in a study with collegiate female athletes in high ACL injury risk sports, Hoog et al., (2016) found that the SLHD did not assess asymmetry to the same degree as alternative movements, such as the Tuck Jump Assessment (TJA). However, despite these non-significant findings, the authors suggest that clinically relevant differences may still be observable using the SLHD. Like the SLCMJ, Barber-Westin et al., (2005) reported that variations of the side-hop SLHD induced lateral and medial forces, that younger participants (9-10 years of age) would not be able to counteract, making balancing difficult. Although one may argue that this assessment is more ecologically valid, the inability to gather consistent data from hop tests inducing lateral and medial forces and thus postural sway, questions the use of the SLHD over some other single-leg NSTs. Moreover, like the SLCMJ, the SLHD evidenced between-limb asymmetry in the majority of both male and female footballers aged 9-10 years old, suggesting that the majority of participants would be required to undertake further neuromuscular training as a result of undergoing the SLHD assessment.

Male youth footballers who demonstrated greater asymmetry during the SLHD are at a higher risk of lower-limb injury (Read et al., 2018). Moreover, male participants were also reported to have a greater risk of sustaining an ankle sprain if they performed poorly on the SLHD, potentially due to reduced ankle stability (McCunn et al., 2018). Although the authors caution the generalisability of this research outside of male, semi-professional footballers, Hegedus et al., (2015) concluded that the SLHD demonstrated enhance evidenced compared to other hop assessments and thus could be utilised to monitor rehabilitation progress in injured participants. However, it is still

unclear as to the magnitude of the minimal important change (MIC) or the smallest detectable change (SDC) needed in any hop test to be able to monitor this progression (Hegedus et al., 2015).

With a cohort including over 100 female participants (mean age 16.7 ± 3.0 years), Paterno et al., (2017) found that the performance of SLHD (triple hop) correlated with increased risk of ACL injury. However, their test protocol investigated the ability of the SLHD to identify participants at risk of a second ACL injury, and thus these results may not be generalisable for participants with no current history of ACL injury.

Of note, single effort tests resulted in greater between-limb asymmetry scores compared to triple hop variations (0.7–25% vs 0.3–14.2%) when assessing young female footballers (mean age 10 ± 1.1 years) (Bishop et al., 2021). This information is of importance, especially for the grassroots coach, where the lack of contact time with players was found to be a barrier for the completion of screening (see Chapter 3).

2.3.3.3 Assessment of ligament dominance

Ligament dominance is a term given to the valgus collapse of the knee upon impact (Hewett et al., 2010). This valgus collapse is more common and pronounced in female participants and is mainly due to the muscles' (namely the gluteals, hamstrings, gastrocnemius and soleus) inability to sufficiently absorb the ground reaction force (Hewett et al., 2010). The additional strain placed upon the ligaments may increase the likelihood of ligamentous rupture (Hewett et al., 2010).

2.3.3.3.1 Landing Error Scoring System (LESS)

2.3.3.3.1.1 Reliability of the LESS and LESS Real-time

In a large study with over 2700 military academy participants (including over 1000 females, age not reported) the LESS demonstrated good to excellent intrarater and interrater reliability. Additionally, the LESS was validated against the gold standard measure of three dimensional kinematic and kinetic analysis (Padua et al., 2009). Intrarater reliability was assessed by repeated measures scored by a single rater, whereas interrater reliability was assessed by agreement between two raters. The skill and experience level of the raters in the work of Padua et al., (2009) remains unclear. Prior to the assessment of reliability, the authors trained the raters by way of a presentation, with a summative assessment comparing the scores of the trainee raters with expert raters. It could therefore be argued that the raters could be termed novice raters, although it is not documented if the raters had previous experience of other movement assessments (i.e. were sports coaches, physiotherapists etc). However, it has been maintained that the LESS can be used by both novice and expert raters with excellent reliability (Chimera & Warren, 2016).

Whereas the traditional LESS required video cameras to record motion from both the frontal and sagittal planes, a modified version of the LESS, the LESS real-time (LESS-RT) was developed, scoring 10 errors during real-time performance. The LESS-RT was assessed as being good for both interrater reliability (Padua et al., 2011). Yet the raters used in this study were "certified athletic trainers with over 5 years of clinical experience and had previous training and experience with scoring the original LESS from video replay (each rater has scored over 200 separate subjects)" (Padua et al., 2011, p. 146-147). Unlike the LESS, which has been shown to have excellent interrater reliability when comparing novice and expert raters (Onate et al., 2010), the reliability of the LESS-RT when assessed by novice users has not been thoroughly established, a point confirmed by the authors (Padua et al., 2011). However, the fact that LESS-RT scores correlate with LESS scores, showing good interrater reliability, coupled with good interrater

reliability of the LESS-RT by experienced raters (Padua et al., 2011), suggests novice users may also be able to score the LESS-RT accurately and reliably.

2.3.3.3.1.2 Use of the LESS and LESS-RT in grassroots football

Initial research on the LESS demonstrated concurrent validity where Padua et al., (2009) reported that participants with low LESS scores demonstrated reduced knee and hip flexion angle, increased knee valgus and hip adduction angle, increased internal knee and hip internal rotation moment, and anterior tibial shear force (Chimera & Warren, 2016 p. 211). In contrast to the FMS, the authors also confirmed that some elements of the LESS could be removed from the scoring criteria to improve validity (Padua et al., 2009). As the most common mechanism for non-contact ACL injuries involves jumping (Onate et al., 2010) this strengthens the ecological validity of the LESS. While concurrent validity was reported in the study of Padua et al., (2009), the ages of the participants in the study were not reported, and hence the ability to use the LESS to assess adolescent female footballers was yet to be established.

The validity of the LESS for use with male and female youth footballers was assessed by Padua et al., (2015). With a study cohort comprising over 481 adolescent females (mean age 13.9 ± 1.8 years), Padua et al., (2015) confirmed the ability of the LESS to discriminate between participants with a higher risk of non-contact or indirect contact ACL injuries, proposing participants scoring a five or more could be placed in a higher risk group. Consistent with previous discussions within this dissertation, the results of Padua et al., (2015) should be treated with caution due to the low number of ACL injuries documented during their research period. In a study investigating differing LESS scores of adolescent female participants who competed in either single or multi-sport activities (mean age = 15.05 ± 1.2 years), mean LESS scores for single sport participants with knee-injury histories and single sport participants without knee-injury histories were both above the proposed cut-off of Padua et al., (2015) (7.5 and 6.17 respectively). This suggests that all

participants who compete in a single sport would produce LESS scores requiring additional neuromuscular training, thereby potentially negating the need to conduct the assessment. Moreover, although the LESS has been shown to identify actions associated with higher injury risk, these actions do not necessarily correlate to increased injury rates (Beese et al., 2015).

Although the LESS has been shown to be valid in assessing adolescent female footballers, the video equipment and time costs for assessment ($300-400 and 1-2 minutes per participant – Padua et al., 2015) may make the LESS an unfeasible assessment strategy for grassroots football teams. As a result, grassroots clubs may consider the LESS-RT alternative. Yet, limited research exists regarding the validity of the LESS-RT for injury risk identification and has been highlighted as an area for future research (Padua et al., 2015; Padua et al., 2011). To partially address this knowledge gap, Ogul and Ercan (2022) compared the scores of male and female participants undertaking the LESS-RT. Although the participants in this study were post-adolescent (mean age 21.7 ± 0.9 years), results demonstrated that females scored higher (worse) on the LESS-RT compared to males. This trend is consistent with LESS scores, where young adult female participants score higher (worse) than males (Sangjan et al., 2017). As a result, the LESS-RT has been recommended as an easy-to-use tool to assess biomechanical performance (Oğul & Ercan, 2022), which could lead to individualised corrective neuromuscular training programmes being developed.

2.3.3.3.2 The Drop Jump Screening Test (DJST)

2.3.3.3.2.1 Reliability of the DJST

As part of a longitudinal study investigating how maturation affects vertical jumping and landing forces on adolescent male and female participants (mean age of the 16 female participants = 12.6 ± 1.0 and 13.6 ± 1.0 years), Quatman et al. (2006) reported strong reliability of the drop vertical jump manoeuvre (ICC range = 0.89–0.98). However, the work of Quatman et al., (2006) does not outline the assessment procedure for the DJST in relation to if the DJST was assessed in real-time,

or retrospectively via video analysis. Additionally, the experience level of the raters was not outlined.

Both intrarater and interrater reliability of the DJST has been reported by Lindblom et al., (2021), using a cohort including 49 adolescent female footballers (mean age = 14 ± 1 years). Results showed that the DJST had substantial to almost perfect intrarater and interrater agreement when assessed in real-time (by way of video analysis) by raters who had previous experience of general movement screening (all raters were sports physiotherapists). Indeed, the authors noted that the level of reliability maybe due to the experience level of the raters used. These results confirmed the findings of Nilstad et al., (2014), who also found substantial to almost perfect interrater agreement between three raters who assessed elite female footballers (mean age = 23 ± 5 years) in real-time via video analysis. Again, raters were experienced physiotherapists, suggesting a need for the assessor of the DJST to have significant previous experience.

Whilst the majority of research into the reliability of the DJST has focused on two-footed landings, Stensrud et al., (2011) assessed the reliability of the single-legged DJST, finding that this assessment of knee control was unreliable due to the divergence of results away from gold standard measures such as 2D and 3D analysis (particularly in the 2D frontal plane) as well as the two-footed DJST.

2.3.3.3.2.2 Use of DJST in grassroots football

The validity of the DJST for assessment for youth athletes is assumed due to its development for assessment with this specific age group (Chimera & Warren, 2016). The DJST was found to be an acceptable tool for assessment of knee control in elite, post adolescent (mean age = 22 ± 4 years) female handball players (Stensrud et al., 2011). However, there is a general paucity of literature fully validating the DJST, especially as a tool that can help identify higher injury risk groups in football (Chimera & Warren, 2016).

Edwards et al., (2010) suggests that the DJST assessment should replicate game-like situations as much as possible, yet the differences in kinetic, kinematic and muscle recruitment strategies of different landings may result in the assessment of the two-footed DJST not being considered as ecologically valid for the assessment of footballers. Indeed, the results of the DJST has been shown not to correlate to other football-specific performance criteria for youth female footballers (such as sprinting ability), and thus other assessments, such as the TJA, maybe more ecologically valid for the assessment of footballers (Sonesson et al., 2021). This argument is maintained due to the common unilateral horizontal and vertical movements that take place during football gameplay (McCunn et al., 2017), whereas the DJST was designed specifically not to include horizontal movements (Myer et al., 2013). The starting position of the DJST requires participants to stand motionless on the platform before dropping down to the ground. The passive starting position of the DJST may result in artificially induce feed-forward stabilisation mechanisms that could be considered a learned skill (Read et al., 2016) thereby further reducing the ecological validity of the DJST for footballers who would never perform such actions from such starting positions in game-situations. Additionally, as these learned skills could be developed during maturation (Read et al., 2016), this further questions the use of the DJST for assessment for adolescent populations. To this end, authors recommend repeated plyometric movement assessments in lieu of single action/efforts assessments (Fort-Vanmeerhaeghe et al., 2017).

While the DJST can be a general indicator of lower-limb mechanics for youth footballers (between the ages of 9 - 19 years), the use of the DJST as a tool to identify injury risk has not been supported (Barber-Westin et al., 2005). Yet other authors have demonstrated that injured and uninjured adolescent athletes (including female footballers) perform differently on the DJST (Smith et al., 2017). In fact, the DJST was able to identify differences in female participants with patellofemoral pain (Galloway et al., 2018). Females land with greater valgus knee angle compared to males, which has been linked to greater risk of ACL injury (Myer, et al., 2011b). As the ACL bears more loads

than the medial collateral ligament (MCL) during the DJST (Schilaty et al., 2018), potentially, the results of the DJST could be used to stratify injury risk. However, the results of Schilaty et al., (2018) focused on mature adult females (mean age = 40.0 ± 9.0) rather than those of an adolescent age. Moreover, as results show that 93% of females aged 9 – 10 years old demonstrate marked valgus alignment during the DJST (Barber-Westin et al., 2005), one may conclude that the test protocol is not needed to recommend further neuromuscular training for most juvenile female participants. Concluding this argument, Noyes et al., (2005) suggests that the DJST should not be used to identify knee injury risk.

Good to moderate correlations between 3D motion analysis and 2D video has been reported. (Nilstad et al., 2014). Moreover, real-time assessment via the DJST has been suggested to identify those individuals with high knee abduction moments during a vertical drop-jump task (Nilstad et al., 2014). These two points suggest that a modified version of the DJST could be used in a more field-based setting. However, the test protocol and equipment needed (including a 30.48cm platform, as well as video analysis) to undertake the real-time DJST may make this assessment unfeasible for grassroots football. The DJST is rarely conducted outside of a laboratory environment (Edwards et al., 2010). Additionally, the resultant exercise recommendations from the DJST assessment maybe questioned due to these protocols being written by a single research group (Chimera & Warren, 2016).

2.3.3.3.3 Tuck Jump Assessment

2.3.3.3.3.1 Reliability of the TJA

Although intrarater reliability for the TJA was reported to be high post pilot testing (Hewett et al., 2010), more recently, reliability has been reported to be poor for the TJA (ICC = 0.47) (Chimera & Warren, 2016) with moderate interrater and intrarater reliability reported from raters of different educational and clinical backgrounds (Dudley et al., 2013). Additionally, research assessing the

interrater reliability for the TJA on athletic populations is lacking (Mayhew et al., 2017). When used to assess male youth footballers, the total score obtained via repeated TJAs resulted in moderate ICC values (Read et al., 2016). Read et al., (2016) proposed that part of the reason for the poor interrater and poor to moderate intrarater agreement could stem from the complexity of the TJA itself - demanding dynamic jumping and landing, proprioceptive in kinaesthetic feedback and reflex muscle responses (Read et al., 2016) - all adding variance to the TJA assessment. It has been proposed that during reliability studies, one rater may score a movement flaw if they see it on one occasion during the multiple jump assessment, whereas other raters may only score this same movement score if they observe the flawed pattern on each attempt of the jump (Dudley et al., 2013). The current published protocol for the TJA is not sufficient to allow for consistent TJA scoring, with the TJA not a reliable assessment tool regardless of rater experience (Nilstad et al., 2014; Dudley et al., 2013). Whereas Read et al., (2016) noted poor intrarater and interrater liability of composite TJA scores, intrarater and interrater reliability agreement for the separate items of the TJA has been shown to range between poor to almost perfect (Lindblom et al., 2021). These results suggest that caution is needed when interpreting the composite TJA score, with a preference to analysing individual TJA action scores (Lindblom et al., 2021).

To reduce the complexity of the TJA, the Modified Tuck Jump Assessment (mTJA) was developed (Fort-Vanmeerhaeghe et al., 2017). Using a population of 12 male and 12 female elite youth volleyball players (mean age of female athletes = 15.70 ± .94), Fort-Vanmeerhaeghe et al., (2017) found that both intrarater and interrater agreement was good to excellent for most induvial items on the mTJA and the ICC for intrarater and interrater agreement for the composite mTJA was excellent. Although encouraging, the results could be viewed with caution due to the low sample size in the study. Firstly, the number of jumps assessed by the raters is not known. If the sample size of jumps was below 50, the levels of agreement in the study of Fort-Vanmeerhaeghe et al., (2017) could be because of chance (Mayhew et al., 2017). Additionally, the agreement between

scores obtained via video playback (as used in the study of Fort-Vanmeerhaeghe et al., 2017) compared to assessments scored in real-time is not known. Finally, there were only two raters in the study, who were experienced strength and conditioning coaches, potentially suggesting that the mTJA requires experience to be scored reliably. However, when discussing the level of experience required to assess the TJA, Nilstad et al., (2014) found that there was no link between experience level of the rater and accuracy of scoring, suggesting that the TJA and its variants could be used successfully by novice raters.

2.3.3.3.3.2 Use of the TJA in grassroots football

The TJA is designed to assess lower limb landing kinematics during plyometric activity (Chimera & Warren, 2016). Additionally, the repeated effort nature of the assessment (requiring 10s of repeated effort) will help include fatigue, common in many sports such as football (Chimera & Warren, 2016; Fort-Vanmeerhaeghe et al., 2017). Although the validity of the TJA has not been formally assessed (Chimera & Warren, 2016), this suggests the TJA has improved ecological validity over alternative jump assessments, such as the DJST. Chimera and Warren (2016) suggest that face validity of the TJA is unquestioned, and its ability to assess multiple technical flaws (ligament dominance, quadriceps dominance, leg dominance, trunk dominance and overall technique - Chimera & Warren, 2016) makes the TJA an attractive assessment tool for practitioners. However, not all the technical flaws mentioned above have been substantiated via biomechanical analysis (Chimera & Warren, 2016).

Unlike the DJST, the TJA requires video assessment on two planes (sagittal and frontal) (Chimera & Warren, 2016). This may decrease its use within grassroots sport due to the additional time (approximately 12 minutes to conduct and score per participant – Chimera & Warren, 2016) and equipment needed to conduct assessments. One of the scoring criteria of the TJA is excessive

landing noise (Lindblom et al., 2021), and therefore, analysis may have reduced validity and reliability if conducted retrospectively.

Like the DJST, the TJA has not been validated as a tool that can highlight increased injury risk in participants (Chimera & Warren, 2016). The TJA composite score of <6 did not help identify female footballers (mean age = 20 ± 2 years) who were at an increased risk of sustaining a primary or secondary knee injury (Fältström et al., 2021). However, there are recommendations that the TJA can be used to both identify injury risk and monitor performance. There were weak to moderate correlations between performance tests and the TJA in adolescent male and female footballers (mean age of 49 female participants = 14.0 ± 0.7 years) (Sonesson et al., 2021). Additionally, unlike the DJST, the TJA revealed reduced neuromuscular control in girls compared to boys, proposing its ability to be used as a performance screening tool (Klugman et al., 2011). Adolescent female footballers (mean age of intervention group = 14.1 ± 0.4 years) were found to commonly demonstrate the neuromuscular flaws of 'lower extremity valgus at landing' and 'thighs not reaching parallel to the ground' (Klugman et al., 2011). Moreover, female athletes in high injury risk groups have been shown to perform worse on the TJA, suggesting its use for injury risk identification (Hoog et al., 2016). As excessive knee valgus can be identified in youth footballers via the 'Knee and thigh motion' element of the TJA (Mayhew et al., 2017), and excessive knee valgus angle has been linked to increased knee injury (Hewett et al., 2010), there is potential to use the TJA (or elements of the assessment) to identify increased injury risk in youth footballers.

2.3.3.4 Assessment of dynamic stability

2.3.3.4.1 The Star Excursion Balance Test and Y Balance Test

Balance and stabilisation assessments have regularly been used to assess movement competence in both healthy and injured populations. The Star Excursion Balance Test (SEBT) and Y Balance

Test (YBT) have seen the most attention in literature. Both tests have been purported to assess dynamic balance and strength, requiring the participants to utilise visual, vestibular and somatosensory systems to complete the assessment (Ko et al., 2020; Philp et al., 2020). Assessors can report maximal reach distance measured in specific reach directions and calculate composite scores as well as side-to-side asymmetries in the anterior reach direction (Bulow et al., 2019). The assessments are indicative of the participant's muscular strength, co-ordination, kinaesthetic awareness and functional capacity (Philp et al., 2020).

2.3.3.4.2 Reliability of the Star Excursion Balance Test and Y Balance Test

Both the SEBT and YBT have been shown to be reliable assessments (Plisky et al., 2006; Philp et al., 2020). Although some authors state that the assessments can be used for injury prediction (Plisky et al., 2006), others note that the propensity of researchers to include participants with current or past injury pathology may limit the ability of the SEBT and YBT to be used to identify higher injury risk stratification (Leeder et al., 2016).

The SEBT requires participants to reach out in eight separate directions while standing on one leg, with the distances being recorded. To increase the SEBT's usability, the modified SEBT (mSEBT) requires participants to only complete three of the eight actions (anterior, posterior-medial, and posterior-lateral reach directions). The mSEBT has been shown to be more time efficient yet still produce reliable interrater results (Chimera & Warren, 2016; Bulow et al., 2019). Based upon the SEBT, the YBT requires participants to also reach in the three directions, pushing a measuring instrument with the non-standing foot. The YBT has been reported to produce higher interrater reliability than the SEBT, which is potentially because of the instrumentation used during the YBT (Chimera & Warren, 2016). Moreover, the YBT demonstrates greater scores than the mSEBT (except for the anterior reach) (Chimera & Warren, 2016). Some authors suggest that the reasoning for this increased performance during the YBT is due to the instrumentation, in that the increased

kinaesthetic focus/control required to push the measure may increase sensory feedback, and thus test performance (Ko, et al., 2020).

2.3.3.4.2.1 Use of the Star Excursion Balance Test and Y Balance Test in grassroots football

Plisky et al., (2006) proposed the ability of the mSEBT to identify high school basketball players at a higher risk of injury. Whilst the age of the participants was not directly reported, they could be estimated to be between 14-18 years old based on the American school system. Although questions can always be raised regarding the legitimacy of the self-reporting injury protocols used, the authors attempted to create a robust injury surveillance system. With over 105 of the 235 participants being female, there is possibility to extrapolate this data for adolescent female footballers. Plisky and colleagues (2006) concluded that decreased right anterior reach distance and greater anterior right/left distance difference (of >4 cm) was able to discriminate between those participants with a higher injury risk. The authors found that females with a composite reach distance <94% of their limb-length were over six times more likely to experience injury to the lower-limb. The authors conclude that this finding may help assessors use the mSEBT to determine the neuromuscular training requirements of participants.

Using a cohort of healthy adolescent females, Bulow et al., (2019) found that participants performed differently on both assessments when compared to an adult population. As healthy adult populations have been shown to produce differing reach distances and kinematic profiles between the mSEBT and YBT, this suggests that the assessments should not be used interchangeably (Bulow et al., 2019). Although noting their sample size as a limitation to their study (specifically for composite scores and side-to-side asymmetry), the researchers found that the cut-offs (>4 cm difference, previously reported by Plisky et al., 2006) resulted in inconsistent risk stratification. Moreover, the authors concluded that the 94% reach to limb-length ratio is different for each test, again strengthening the assertion that only one assessment should be used

consistently. Emphasising this point, Bulow et al., (2019) reported that five of their participants were identified in the higher-risk category using the mSEBT, whereas only four participants were identified in the same risk category when using the YBT. Of note, only one participant was identified at higher risk via both assessments.

The validity of using the mSEBT participants with a history of previous injury has been questioned (Leeder et al., 2016). Ko et al., (2020) investigated how history of ankle sprains would affect performance on the SEBT by male youth footballers. This is an important consideration as, although research on ACL injury in female footballers receives significantly more attention within literature, ligamentous sprains are the most common injury sustained in football (Herman et al., 2012; Rössler et al., 2016a), with injury to the ankles and feet the most common injury sites (Faude et al., 2013). Injury to the ankle was the second most common site for time-loss injuries and more severe injuries in adolescent females (Clausen et al., 2014). Therefore, the ability of the mSEBT to be utilised for participants with a history of ankle injury is of paramount importance for its continued use within female adolescent football. Ko et al., (2020) deduced that participants with a history of ankle injury performed worse on sections of the mSEBT. This would allow practitioners to identify those participants with unresolved strength or proprioceptive ankle issues.

The ability of the previously reported cut-offs (94% of limb length and >4 cm right/left difference) to be generalise to adolescent female populations has been questioned by Philp et al., (2020). During maturation, females see a reduction in sensorimotor functions of the lower limbs, requiring increased reliance on visual cues (Bulow et al., 2019). This maybe another reason why the scores for the YBT exceeded those of the mSEBT. Using adolescent female footballers aged between 13 and 18 years old, Philp et al., (2020) found that age did not differentiate between mSEBT. This would mean that the mSEBT could be used consistently during maturation, although cautiously, as adolescent females have been reported to start puberty below the age of 13 (Schiff et al., 2010).

In conclusion, both the mSEBT and YBT have been shown to be reliable assessments. Although the YBT producers greater scores, these scores should not be viewed outside the parameters of the specific assessment. Normative values for adolescent female footballers completing the mSEBT increases its generalisability. Moreover, although the instrumentation used in the YBT may increase both speed of assessment and aid more consistent measurements, this time saving maybe negligible and its cost may be restrictive for grassroots football clubs compared to the mSEBT which requires limited equipment (Bulow et al., 2019). While the mSEBT necessitates minimal equipment, the precision required for establishing the measuring grid, including the exact 135° angle between markers, might discourage grassroots coaches from fully adopting the mSEBT. This, in turn, could lead to inconsistencies in measurements between tests throughout a season, diminishing its effectiveness in progress monitoring. Evaluating dorsiflexion ability can be achieved through the anterior reach section of the SEBT (Hoch et al., 2011). Considering that dorsiflexion is linked to injury risk (Fong et al., 2007; Malloy et al., 2015), using the anterior reach to assess dorsiflexion may enhance the screening's capability to stratify injury risk. It has already been suggested that heightened between-limb asymmetry during the anterior reach movement of the mSEBT is associated with an increased risk of injury (Plisky et al., 2006; Smith et al., 2017). Furthermore, youth footballers with a history of lateral ankle sprains, the most common injury in football, exhibit reduced anterior reach distances (Faude et al., 2013; Nagamoto et al., 2021). Given the above, researchers have proposed restricting the mSEBT to a single direction (the anterior reach) to address this issue (McCunn et al., 2017).

2.3.4 Validity of screening tools in the female grassroots game

The concept of validity is central to determining whether any screening tool is fit for purpose. In female grassroots football, validity refers not only to the accuracy of a test but also to its appropriateness, applicability, and meaningfulness within this specific context (Mokkink et al., 2010). While section 2.3

reviewed the validity of individual neuromuscular screening tools (NSTs), it is also necessary to critically evaluate whether such tools, as a concept and practice, are suitable for grassroots use.

Construct validity concerns whether a tool measures what it claims to (Mokkink et al., 2010). For NSTs, this involves assessing whether they accurately identify neuromuscular deficits or movement patterns linked to injury risk. Research identified imbalances such as quadriceps dominance, ligament dominance, and poor dynamic stability as key contributors to lower-limb injuries, especially ACL injuries in female athletes (Hewett et al., 2005): Myer et al., 2008). While ACL injuries are less frequent at grassroots level (Hägglund & Waldén, 2016), their severity justifies early identification. Tools like the LESS and TJA have demonstrated good construct validity in detecting these high-risk movement patterns (Padua et al., 2009; Fort-Vanmeerhaeghe et al., 2017).

Ecological validity refers to how well a tool fits its real-world setting (Chimera & Warren, 2016). Though many NSTs were developed in elite or clinical environments, they remain relevant to grassroots football because key neuromuscular risk factors are consistent across performance levels. Female adolescents face maturational and biomechanical changes (i.e. joint laxity, hormonal fluctuations, coordination deficits) that elevate injury risk regardless of playing standard (Quatman et al., 2006; Alentorn-Geli et al., 2009). Therefore, adapted or simplified tools can be valid in grassroots contexts, enabling evidence-based injury prevention.

A common concern is whether grassroots coaches, often volunteers with limited training, can reliably use these tools. However, tools like the LESS-RT and SLBT have been designed for minimal equipment and training (Padua et al., 2011; Freckleton et al., 2014). While novice assessors may vary in accuracy, this can be mitigated through short training and standardised protocols (Onate et al., 2012). This relates to practical validity - whether a tool is feasible and useful in day-to-day practice (Gersbach, 2016). When paired with brief, targeted education, NSTs can be integrated into grassroots coaching without major time or resource demands.

Social validity is also critical. Female grassroots football has historically lacked access to injury prevention tools and resources compared to the male game (De Ste Croix et al., 2020). Introducing NSTs can help redress this imbalance, allowing coaches to take a proactive role in promoting player health. Donaldson et al. (2018) argue that youth injury prevention is as much about shaping environments and behaviours as delivering specific exercises. NSTs, when combined with education, signal a commitment to wellbeing and normalise conversations around injury risk, enhancing their perceived legitimacy.

Some critics argue that screening tools cannot predict injuries. Bahr (2016) rightly points out that injury is multifactorial and unpredictable. However, this does not undermine NSTs, it simply reframes their purpose. Rather than predicting injury, they identify modifiable deficits that, if addressed, can improve movement quality and reduce injury risk (Sugimoto et al., 2015). Improving neuromuscular control can enhance overall athletic resilience, even if injury risk cannot be fully eliminated.

Criterion-related validity is also relevant. Although NSTs are not perfect predictors, the interventions they inform can produce positive outcomes. For example, studies by Soligard et al. (2008) and Myklebust et al. (2003) demonstrated that neuromuscular training informed by screening can reduce injury rates by up to 50% in female youth players. In grassroots contexts - where medical support is limited - even basic screening can help coaches prioritise players most in need, allowing efficient use of limited time and resources.

Crucially, validity must be judged in context. In elite sport, high sensitivity and specificity are essential. In grassroots football, however, the goals are broader: improving movement competence, reducing injury risk, and promoting safe, enjoyable participation. A tool that supports these outcomes is valid for this environment, even if it lacks the diagnostic precision demanded in professional settings. As Gersbach (2016) suggests, validity is shaped by the purpose and setting in which a tool is used. NSTs also align with the long-term athletic development (LTAD) model, which promotes the progressive, age-appropriate development of movement and physical literacy (Lloyd et al., 2015). Early identification of movement issues allows for timely corrective strategies that reduce injury risk and improve long-term athletic potential. In

grassroots female football, where many players are new to structured sport, this supports the development of safe, effective movement habits from a young age.

Thus, NSTs are both valid and valuable in female grassroots football. They show strong construct validity by targeting known risk factors, offer ecological and practical validity when adapted to the environment, and hold social and developmental value by addressing inequalities and aligning with LTAD principles. While no tool can fully predict injury, NSTs represent a feasible, context-appropriate, evidence-informed strategy to enhance safety, movement quality, and long-term player development in an underserved population.

2.3.5 Section summary

The literature highlights the utility and limitations of NSTs in assessing injury risk and movement competence, particularly for adolescent female footballers in grassroots settings. While full body screens such as tools like the FMS demonstrate reliability, their sensitivity for detecting poor movement patterns in adolescents is questionable, and the lack of sport-specific movements diminishes their relevance. Similarly, tools like the AAA and RTSB/RTSBc offer promise but lack validation for football-specific applications and younger populations.

In terms of individual screens for specific risk factors, strength assessments, including HHDs, NHL and SLBT, offer practical and cost-effective options for evaluating hamstring function. While these tools are accessible for the grassroots coach, their predictive accuracy for football-specific demands, particularly under fatigue, requires further study. Similarly, single-leg hop tests such as the SLHD effectively highlight asymmetries but face methodological challenges in younger participants. Landing assessments, including the LESS and DJST, demonstrate reliability in identifying high-risk movement patterns but lack ecological validity for dynamic football actions.

The TJA shows potential due to its repeated-effort design but requires refinement to improve usability and reliability for novice raters. Balance and stabilisation tests, such as the SEBT and YBT, are reliable but face practical challenges. Although these tools effectively measure dynamic balance and strength, inconsistencies in scoring thresholds and test setups limit their value for injury risk stratification. The mSEBT, with minimal equipment requirements, is more accessible for grassroots settings. For athletes with ankle injury histories, the anterior reach component provides valuable insights, though its use as a standalone assessment requires further validation.

It is additionally important to consider the broader validity of NSTs in female grassroots football as a whole. Validity in this context extends beyond technical accuracy, encompassing how appropriate, meaningful, and feasible these tools are within the realities of grassroots settings. While individual NSTs may have design or application challenges, they hold strong construct, ecological, practical, and social validity when applied carefully and supported by coach education. Importantly, even if NST cannot "predict" injury, NSTs enable coaches to identify modifiable deficits, improve movement quality, and deliver targeted interventions aligned with LTAD principles. Taken together, this reinforces that well-chosen NSTs are valid and valuable additions to the female grassroots football environment, contributing to safer participation and more effective player development.

Despite significant research into NSTs, there remains a notable gap in the development of sport-specific, validated tools tailored to adolescent female footballers. No single screening method or whole-body assessment has proven to be perfectly suited for use by grassroots coaches working within this demographic. To address these limitations, future research should prioritise identifying the most appropriate individual screening components and integrating them into an NST specifically designed to meet the needs of the grassroots coaching environment. This tool should

be practical, cost-effective, and user-friendly, accommodating the constraints and expertise of volunteer coaches while ensuring effectiveness in identifying injury risk and guiding training interventions.

2.4 Considerations for football coach development

An estimated three million adults in the UK have conducted some form of sports session within the past year, despite 54% of these adults possessing no formal coaching qualification (Thompson et al., 2020). As most high-performance coaches hold prerequisite qualifications, it is suggested that it is at the grassroots level where these unqualified coaches are more likely to be active (Thompson et al., 2020). The regulation of coaching by NGBs is a continuing concern (Twitchen & Oakley, 2019). Coaches have cited the cost of training, additional commitments and the voluntary nature of their role as the main barriers to their coaching role (Thompson et al., 2020). As 38% of volunteer coaches were from low socioeconomic backgrounds (UK Coaching, 2022), this emphasises that the cost of training is a significant barrier for coach development. This section will discuss professional development considerations for grassroots football coaches in the UK.

2.4.1 Formal, non-formal and informal education and training

When developing a CPD session for coaches, consideration needs to be given to whether the session is viewed through a 'education' or 'training' lens. Whilst education and training are related concepts, they have distinct differences in terms of their scope, purpose, and outcomes.

Education is a broader concept that focuses on the overall development of a coaches' intellectual, social, emotional, and cultural aspects. It involves gaining knowledge, understanding concepts, and developing critical thinking skills in order to foster personal growth and enable coaches to think critically, analyse complex situations, and engage in a variety of disciplines. Training has a narrower concept that is focused on specific skills and techniques related to coaching or an aspect of coaching, aiming to improve a coaches' proficiency in performing specific tasks by enhancing practical skills, knowledge, and abilities required for a particular aspect of coaching (Mallett et al., 2009). Education is usually long-term and may involve following a curriculum, leading to a measure of learning, assessed by the completion of assignments and exams etc., whereas training is usually of shorter duration and may not necessarily require summative assessments of knowledge developed (Mallett et al., 2009).

2.4.1.1 Formal learning

A further breakdown of educational methodologies has been applied, with education being subdivided into 'formal', 'non-formal' and 'informal' opportunities, a conceptual framework that has general acceptance within andragogical research (Cushion et al., 2010). 'Formal learning' follows the 'traditional' definitions of education outlined above and are usually delivered by NGBs (Leeder et al., 2021). However, as the term education sites the ability to think critically, analyse complex situations etc., formal coach education sessions have been said to more closely resemble training due to the delivery of sequential and standardised components, potentially leading to indoctrination (Leeder et al., 2021). Indeed, this linear delivery of coach education is flawed as it fails to acknowledge how social and cultural contexts influence learning (Leeder et al., 2021). Coach learning is said to be idiosyncratic (Leeder et al., 2021) yet the previous learning journey of coaches is not considered by formal education, meaning many coaches arrive at formal training already knowing much of the content covered, with content decided and designed by those in power

(Cushion et al., 2010; Dempsey et al., 2020). This could result in formal education courses' where content is too basic or abstract from the daily reality of coaching, and thus many coaches only attend formal education courses due to obligation (Cushion et al., 2010; Piggott, 2012).

From an andragogical perspective, formal education has been criticised as being too formulaic in that participants are simply expected to take in disseminated information (usually revolving around the 'ologies - biomechanics, psychology, physiology etc.) and to regurgitate such knowledge following the structure that is outlined during the coach education training (Piggott, 2012). Indeed, Leeder & Cushion, (2020) suggest that formal coach education courses could be classed as 'closed-circle' in nature, and that in order to successfully pass the course, coaches must uncritically accept the content and thus will regurgitate an "NGB enforced professional dogma (in order) to secure accreditation" (p. 274). Due to the volunteer nature of the grassroots coaching workforce, many coaches will be engaged with informal experiential learning prior to attending any formal courses (Webb & Leeder, 2022), which suggests that the formal style of learning required to undertake and pass such courses will be juxtaposed to the coaches' current preferred method of learning.

Yet there are potential benefits to formal coach education regarding coach learning. Stodter and Cushion (2019) found that experienced coaches (mean = 7.9 years' experience) did report that a formal NGB coaching qualification influenced coaches' practice. Additionally, coaches were able to adapt and implement new knowledge learnt via formal education into practice without having to challenge their previously held core assumptions. This is important as challenging and changing such deep-seated values or assumptions is rarely possible in a short course-format (Stodter & Cushion, 2019). Moreover, while informal learning still resulted in a richer learning experience, expert coaches acknowledged that formal learning improved their development (Wright et al., 2007).

2.4.1.2 Non-formal learning

Research suggests that formal coach development courses do little to affect coaching practise in the long-term (Martindale & Nash, 2013), potentially as formal education courses do not allow for experiential learning to be embedded in learning (Mallett et al., 2009). Non-formal learning opportunities have been designed to overcome some limitations in formal education (Mallett et al., 2009), with shorter duration voluntary courses (termed CPD) requiring limited prerequisite knowledge and includes optional coaching workshops, interventions, or content-specific conferences that take place outside of the formal education framework of the NGB (Leeder et al., 2021; Cushion et al., 2010). Yet most of these CPD courses are indeed structured (though not to the same degree as formal educational courses) and can also be of long duration (Mallett et al., 2009). Indeed, (McCaughtry et al., 2005) outlined the characteristics that could be applied to non-formal CPD for coaches, being.

- "short (perhaps one off) workshops with little or no follow-up
- predetermined and highly structured sequences and activities
- didactic instruction with passive learning
- random groupings of teachers
- decontextualised content
- lack of reflection in and on the teacher's own teaching" (Cushion et al., 2010, p. 39)

Cushion et al., (2010) reviews authors who suggested that the non-formal education methodology results in "batch processing" of learners "who are talked at", failing to "build on existing knowledge and skills" (Cushion et al., 2010, p. 39). Moreover, non-formal education has been highlighted as one of the least preferred methods of education or training (Leeder et al., 2021).

However, the reasoning for these low attitudes towards CPD is rarely investigated, with the coaches' perceptions towards the CPD session itself, rather than any assessment of knowledge gained or the CPD's influence on practice being reported (Leeder et al., 2021). Indeed, as the perceptions of the value of the CPD session is associated with the kudos of the tutor (Leeder et al., 2021), research into the transfer of knowledge itself and its impact on coaching practice in the long-term warrants' further investigation. Moreover, learning that takes place outside of the NGB-mandated curriculum (such as with CPD courses) may allow learners to embrace a more open and individualised learning culture (Leeder et al., 2021). The ability to self-select CPD will increase the coaches' perception of the session being beneficial to their everyday coaching role. The positive impact of this voluntary enrolment in training on the successful transfer of learning outcomes has been demonstrated, with learners with elevated motivation levels more inclined to effectively apply the acquired knowledge to their practical endeavours (Nash et al., 2017; Kodwani & Prashar, 2021). Certainly, the motivation level of a trainee is regarded as a fundamental trainee-associated aspect that impacts the transfer of knowledge process (Nafukho et al., 2023).

2.4.1.3 Informal learning

Informal learning is "the lifelong process by which every person acquires and accumulates knowledge, skills, attitudes and insights from daily experiences and exposure to the environment" where coaches learn through a variety of opportunities such as by their experience as a performer and a coach, informal mentoring or interaction with their coaching peers (Nelson et al., 2006, p. 8). From a coaching perspective, informal or self-directed learning takes the form of internet use, literature such as coaching manuals, books and magazines, sport science literature such as peer-reviewed journals and videos of coaching sessions (including their own) (Jones & Allison, 2014).

Whilst structured learning (formal and non-formal) may be classed as 'education', learning via informal situations is generally categorised solely as 'learning' (Mallett et al., 2009). Research indicates that coaches prefer informal learning over other learning opportunities, partly as it is more time efficient (Leeder et al., 2021; Cushion et al., 2010).

An individual's day-to-day coaching experience and the sharing of those experiences with peers is reported to be the most regarded pillar of coach development, where learning usually takes place without the explicit intention of learning (Cushion et al., 2010; Mallett et al., 2009; Nelson et al., 2006; Côté, 2006). As coaching is a complex, context-dependent endeavour (Leeder et al., 2021; Stodter & Cushion, 2014), researchers have suggested that, compared to formal and non-formal learning, informal learning offers the idiosyncratic learning opportunities synonymous with the workings of the vocation (Cushion & Townsend, 2018). Indeed, informal learning is said to occur via engagement in "informal learning networks" or "communities of practice" (Nelson et al., 2006, p. 253) where groups of coaches can swap ideas on practices, drills, resources and share experiences that may help coaches solve specific coaching dilemmas (Nelson et al., 2006). This is achieved by the individual coach having the time to devote to self-directed learning, where they have the space to reflect-in and reflect-on any current or past coaching-related dilemmas (Stodter & Cushion, 2014; Mallett et al., 2009).

From an andragogical perspective, the theoretical framework for informal learning is explained by Gilbert and Trudel's (2001) experiential learning model (Cushion et al., 2010). Gilbert and Trudel's (2001) model propose a conceptual framework of how youth sports coaches developed knowledge and skills via experience, comprising of six components. The first three components of (1) coaching issues, (2) role frames, (3) issue setting, relate to the experience of the coach, with the

final three components - (4) strategy generation, (5) experimentation, and (6) evaluation relating to the sub-loop of a reflective cycle (Côté, 2006).

Whilst evidence suggests that coaches prefer an informal approach to learning, this learning strategy is not without its limitations. Mentoring is often the most visible method of informal learning. Yet mentoring itself has been criticised by authors (Stoszkowski & Collins, 2016; Jones et al., 2009). For example, while formal learning has been criticised for the potential to indoctrinate coaches into thinking there is a right and wrong way to coach, learning from a mentor may expose the mentee to a similar reinforced perspective of how-to coach (Stoszkowski & Collins, 2016). This is a particular concern due to the power dynamics between the (potentially novice) mentee and the (potentially very experienced and qualified) mentor, where the mentor may 'pass-on' their ideology for the mentee to replicate (Cushion et al., 2010). Indeed, structured mentoring as part of informal learning may ultimately reduce the learning experience for the mentee (Mallett et al., 2009).

2.4.2 A social constructivist coach education approach

Coaches' learning is influenced by social, cultural and political factors, and, as such, it is argued that coach education should be viewed through a social constructivist lens (Chapman et al., 2020; Stoszkowski & Collins, 2016). The above discussion of formal coach education courses suggested an 'instruction-based' approach to learning, in that knowledge is transferred to coaches by tutors (Ciampolini et al., 2019). However, this strategy does not recognise the value of prior knowledge and learning to allow the coach to make sense of their individual social construct (Dempsey et al., 2021). As a result, a move towards a more social constructivist learning paradigm has been suggested (Dempsey et al., 2021). Specifically, this learning paradigm emphasises the relationship

between coach educator and coach, where the coach educators create an environment for the coach to become the co-creator of their learning environment. The coach can utilise their individual experiences, knowledge, values and skills, leading to the construction of new knowledge in a learner-centred approach (Ciampolini et al., 2019).

Ciampolini et al., (2019) conducted a review of coach education literature investigating coaches' perceptions on coach education programmes. The results of their thematic analysis revealed three main themes that coach is perceived to be beneficial within coach education; "(a) Organising interactive activities for learning (interactions with peers); (b) Opportunities for coaches to reflect (reflecting through interaction and reflection through tools); and (c) Assessment practices (feedback from the instructor. These higher order andragogical traits are consistent with the constructivist view of learning (Ciampolini et al., 2019, p. 219), which could be built into coach education session planning. Indeed, the FA now advocate a more social constructivist andragogy during formal coach education (Chapman et al., 2020).

2.4.3 Knowledge development in coach education

In addition to the structural delivery of coach education, further consideration needs to be given as to how coaches acquire new knowledge. When coaches participate in learning scenarios, various personal elements influence whether they accept, adjust, or decline new knowledge (Stodter & Cushion, 2017). An essential factor in this process is the ingrained attitudes and guiding cultural framework of the coaches. Coaching has often unquestioningly reused theories from unrelated fields. For example, concepts like situated learning, communities of practice, and problem-based learning have been incorporated into coach education (Nelson & Cushion, 2013). Yet, due to a

scarcity of direct research, the mechanisms and results tied to coaches' learning related to CPD remains ambiguous (Griffiths et al., 2018).

The distinct biography of every coach is believed to function as a filter or perspective through which they perceive and comprehend new knowledge (Trudel et al., 2013), a view which aligns with the constructionist informed approach to learning (Dempsey et al., 2021). The coach's biography aligns with the habitus concept developed by Bourdieu, (1992). Habitus represents the ingrained set of dispositions, behaviours, attitudes, and preferences that individuals acquire through socialisation and their experiences within a particular social and cultural context. Habitus is not consciously chosen but rather emerges from a person's upbringing, education, environment, and interactions. It shapes how people perceive the world, make decisions, and act in various situations. Habitus plays a crucial role in influencing individual choices, behaviours, and interactions within specific social settings. It's often used to explain why people from similar backgrounds tend to have similar outlooks and behaviours. In the realm of coaching, mentors, for example, hold a substantial role as influential social figures who determine the definition of acceptable knowledge for the student coach (Leeder & Cushion, 2020). When exposed to a new concept, coaches connect fresh learning to existing cognitive frameworks to realign with their own context. Coaches who make modifications in their practice are considered to have undergone cognitive, emotional and practical shifts in their biography. Those who do not change are said to either lack the self-confidence to embrace the 'disruptive' encounter where new information does not align with their past biography, or coaches saw no difference between their current practice and the content covered in the course (Leduc et al., 2012; Stodter & Cushion, 2017).

Stodter and Cushion (2017) outlined a grounded process for how coaches learn and acquire new knowledge. As mentioned above, new knowledge is viewed through the coach's personal

biography and habitus. Matching concepts are accepted and adopted. Matching concepts are likely when a particular piece of knowledge acquired from a learning situation has already been grasped by a coach and this concept already closely aligns with the coach's preexisting cognitive frameworks. This will serve to validate and strengthen the view of that specific area of knowledge, enhancing its likely use by the coach (Stodter & Cushion, 2017). While an individual's habitus can undergo transformation, early experiences and primary habitus often display resistance to change by dismissing information that has the potential to challenge the accumulated knowledge (Leeder & Cushion, 2020). Mismatching concepts are content that clashes with or contradicts the coach's current knowledge, practices, and this new knowledge is swiftly disregarded with coaches maintaining knowledge in accordance with their current biography and habitus (Stodter & Cushion, 2017). However, there are times where the coach may 'cherry-pick' sections of new mismatching knowledge, allowing them to 'practice' with this new knowledge or concepts without conflicting with their current biography (Stodter & Cushion, 2017). This 'cherry-picking' risks the full development of the new concept, limiting its implementation or impact, and thereby confirming the original views of the coach about the mismatching concept (Stodter & Cushion, 2017).

Stodter and Cushion (2017) further develops their model by commenting on situations where matched concepts of new knowledge are still not implemented by the coach. This contextual filter allows the coach to reject any matched information that does not align with their current coaching practice or situation. Indeed, if, in the coaches' view, novel ideas were deemed impractical within a context of their specific circumstances, rejection would occur. Social interactions, such as observing and collaborating with fellow coaches, plays a significant role in shaping these convictions among coaches. Secondary habitus can be formed subsequently through experiences in educational, training, and professional environments (Leeder & Cushion, 2020). Through

working with peers, for example, coaches may find that content peers trusted would not suit their distinct coaching setting, yet may be improved via adaptation of the concept so that it aligns more closely with their current coaching context (Stodter & Cushion, 2017).

Stodter and Cushion (2017) states that once coaches agree that a concept may work in theory, the process of implementation could follow the process outlined by Eraut (2000). Eraut's processes involved four steps: (1) grasping the situation, which necessitates the appropriate application of prior knowledge; (2) identifying the concept or idea as pertinent; (3) adapting it to suit the situation; and (4) merging that knowledge with other insights during the planning and execution of actions (Eraut, 2000).

2.4.3.1 Coaches accessing sport science knowledge

While the accessibility of sport science knowledge and assistance is growing, the provision of funding for such support remains relatively recent in numerous sports (Martindale & Nash, 2013). Furthermore, any funding for sport science support is primarily directed towards coaches and teams operating at an elite level (Martindale & Nash, 2013). Moreover, despite the increase in the availability of sport science knowledge through sources such as the internet, coaches still primarily obtain information from fellow coaches and coaching conferences, with sport scientists and their published works ranking considerably lower as sources of information (Reade et al., 2008). Indeed, a commonly held view is that the transfer of sport science knowledge to coaching is lacking (Bishop, 2008). Additional research revealed that sport science expertise isn't regarded as highly valuable compared to experience and practical knowledge gained through participation and interaction with fellow coaches (Martindale & Nash, 2013). Moreover, the value of incorporating sports science into coach education at grassroots levels has been a subject of debate, and a

considerable number of coaches expressed a lack of comprehension regarding its relevance (Martindale & Nash, 2013).

When investigating the perceptions of a cross-sectional group of coaches regarding sport science knowledge, Martindale & Nash (2013) suggest that coaches might require assistance to grasp and recognise the significance and practicality of sport science. Indeed, coach education programmes could enhance a coach's capacity to employ information and differentiate between what is relevant and irrelevant in specific situations. This approach, which centres on problem-solving and knowledge application, has been previously advocated (Nash et al., 2011). Of note, and contradicting the work of Reade et al., (2008), the perceptions of sport science knowledge was not divided by coaching level (novice, developmental and elite), suggesting a more personal view of sports science knowledge by individual coaches. This ideology aligns with the social constructivist view of learning, in that coaches' past experience could shape their perceptions on current/future sport science knowledge development (Stodter & Cushion, 2017; Ciampolini et al., 2019). Certainly, obstacles to the effectiveness of sport science arose when coaches had encountered past negative interactions with sport scientists in practice (Martindale & Nash, 2013).

2.4.4 Barriers and facilitators in coach education

2.4.4.1 Barriers in coach education

Outside of the epistemological discussions regarding the nature and methodology of learning, coach education, being a multifaceted endeavour involves both operational barriers and facilitators influencing its effectiveness and accessibility. These factors can significantly impact the development of competent and skilled coaches across sport and have been broadly categorised as "(1) situational barriers (e.g., lack of money, time, transportation, etc.); (2) institutional barriers

(e.g., inappropriate course costs, inconvenient course schedules, irrelevant courses of study, etc.); and (3) dispositional barriers (e.g., lack of confidence, desire, interest, etc.)" (Cushion et al., 2010, p. 59).

A study by Sport Coach UK (2004) found that those interested in commencing sports coaching were put off by situational and institutional barriers including cost, location and time (Cushion et al., 2010). The cost associated with coach education programmes that encompass courses, certifications, and workshops, often presents a significant financial barrier. Individuals from economically disadvantaged backgrounds may struggle to afford these programmes, limiting their access to quality education and hindering their coaching aspirations (Thompson et al., 2020; UK Coaching, 2022). While the costs of certification etc. has been cited as a barrier to coach education that may limit accessibility, the geographical availability of coach education programmes can also pose accessibility challenges. Aspiring coaches situated in remote or underserved areas might face limited opportunities due to the lack of accessible programmes nearby, potentially constraining their development (Cushion et al., 2010). Indeed, data collected using a combination of interviews and questionnaires showed that coaches identified course location as an area in need of consideration for course development (Nelson et al., 2013). Coach education taking place "a long way away" coupled with "unsuitable facilities" reduce the educational effectiveness, with coaches advising course designers to "keep it local" (Nelson et al., 2013, p. 215).

Time constraints have 1been consistently documented as a barrier to coach education (Nash et al., 2017). The demands of existing commitments, such as full-time jobs or familial responsibilities, can impede participation in coach education programmes, especially given the voluntary nature of grassroots coaching (Nash et al., 2017). However, given this voluntary nature of grassroots coaching, Nash et al., (2017) questions whether this level of coaching should be seen as a

'profession' and thus postulates as to whether grassroots coaches should be required to undertake regular coach education. Resistance to learning by grassroots coaches may increase because of mandating attendance on CPD courses (Nash et al., 2017).

Another institutional barrier with regards to coach education can be seen through the study of coach development in Dutch football (Conroy & Coatsworth, 2006). Authors found that as the course was designed by the NGB, with limited input from the coaches themselves, the end-user coaches felt that the course did not meet their needs, or the needs of their industry (Jacobs et al., 2015). Formal NGB coach education programmes often follow a standardised and utilitarian approach and are frequently created separately from the complex and unpredictable nature of actual coaching practice (Cushion & Townsend, 2018). Coaches typically extract knowledge from coach education initiatives based on what proves effective within their unique circumstances (Stodter & Cushion, 2014). Indeed, discontentment towards conventional 'in-person' coach education is potentially exacerbated by 'learning' that is guided and moulded within coaching sub-cultures, influenced by the powerbase (i.e., the NGB) (Cushion & Townsend, 2018). As a result, the motivation for attending such coach education sessions diminished (Jacobs et al., 2015). The prevalent design of coaching programmes, often following a top-down model (from scientist to practitioner), limits the amount of learning that can be taken from coach education courses and implemented in real-world situations. Coach education programmes should shift away from resembling conventional 'knowledge transfer' courses and instead adopt a collaborative learning approach which involves the sharing and generation of coaching knowledge within specific contexts (Côté, 2006).

2.4.4.2 Facilitators in coach education

The expertise and experience of instructors significantly contribute to the quality of coach education. Educators possessing substantial knowledge and effective andragogical approaches enhance the learning process and provide invaluable insights to aspiring coaches. Often, the 'cultural capital' of those delivering the course enhance the reputation and noted success for the coach education course (Leeder et al., 2021). A tutor with more cultural capital may have significant standing within the game, having worked with many elite performers and organisations (Leeder et al., 2021). The additional notoriety of 'the badge' (i.e., wearing NGB branded clothing) also enhances the cultural capital of the tutor, leading to increased perceived course value by attendees (Leeder et al., 2021). Coach educators need to be prepared for the course (knowledgeable), with good presentation and communication skills (Nelson et al., 2013). Furthermore, coach educators need to be able to perform good demonstrations, with practical experience, without using wording that is considered too jargony (Nelson et al., 2013).

Aligning with the constructivist learning paradigm, coaches highlight the importance of workshops, conferences, and networking events within the coaching community that foster connections and shared learning experiences. These interactions enable coaches to learn from one another, exchange best practices, cultivate a supportive professional network and thus become more informal learners (Nelson et al., 2013). Indeed, the opportunity to network and for discussion time with other coaches (i.e., during lunchbreaks) was found to be more favourably received by coaches compared to tutor-led sessions (Deek et al., 2013; Jones & Allison, 2014). Additionally, the opportunity to engage with fellow coaches (by way of group-learning and practical activities etc.) have been advocated in literature, with coaches wanting increased opportunity to share ideas and practices with other coaches (Nelson et al., 2013).

It has previously been mentioned that formal education courses, suffer because of mandating that all attendees study the same material, irrespective of their own individual ideology or coaching experience. Formal education courses can often be perceived as being too broad and wide-ranging to be useful for a coaches' personal coaching situation, resulting in poorer appreciation of the coaching course (Nelson et al., 2013). As a result, more tailored programmes that cater for diverse levels of expertise and specialisations would enhance both retention and accessibility. Hence, a CPD training session aimed at movement screening for coaches of adolescent female footballers would be more specialised for coaches (compared to attending a similar session focusing on both sexes and all playing levels), increasing the potential transferability to their sport and improve motivation to attend.

2.4.5 Blended learning in coach education

Blended learning in coach education refers to a teaching approach that combines traditional face-to-face instruction with online learning methods. It leverages the strengths of both in-person interactions and digital resources to create a comprehensive and flexible educational experience and has been shown to be more effective than traditional face-to-face sessions alone (Cushion & Townsend, 2018).

In a blended learning model for coach education, learners engage in a mix of in-person workshops, seminars, or practical sessions, and online components such as virtual classrooms, webinars, videos, and interactive modules. This approach offers several benefits, including accommodating diverse learning styles, providing flexibility for learners to access content at their own pace, and promoting engagement through interactive online activities (Stoszkowski et al., 2017). Blended learning enables coaches-in-training to acquire both theoretical knowledge and practical skills,

often integrating real-world coaching experiences. The model fosters interaction among learners and instructors, as well as peer-to-peer collaboration, contributing to a well-rounded and effective educational experience. However, despite its proposed benefits, research into the effectiveness of blended learning in coach education remains sparse (Cushion & Townsend, 2018).

The use of mentoring has been shown to be beneficial and desirable for informal coach education, yet the use of online systems to allow access to a wider coaching learning community has been shown to be insufficient at creating these informal networks (Cushion & Townsend, 2018). However, others have reported that online tools have shown benefits for coach education in terms of providing structure for reflective conversations, improved self-awareness and that help promote behaviour change in elite youth football coaches (Kanatouri, 2017). Time constraints have been shown to be a barrier for coach education (Cushion et al., 2010), so having an online tool to connect coaches with mentors that can be utilised around external coaching commitments has been highlighted as a potential benefit for overall coach education (Kuklick et al., 2016). However, as the work of Kuklick et al. (2016), was based on a single coach case-study, it is challenging to generalise these results to the wider football-coaching community. Yet when investigating the use of Flipgrid as a tool for coach reflection, Stoszkowski and Collins (2022) noted that 58% of videos were posted after 8pm by coaches. This suggests that coaches were able to complete content at a time to suit their lives whilst still engaging in reflective practice online. Moreover, as coaches suggest that they want a reduction in didactic teaching during coach education sessions (Nelson et al., 2013), the introduction of an online/blended approach to learning may serve to reduce the face-to-face instructional element of sessions, allowing more time and opportunities for coaches to share ideas with coaching peers during practical or face-to-face coach education sessions.

Massive Open Online Courses (MOOCs) have been shown to increase accessibility of course material, via asynchronous access. They allow the course material to be access multiple times, with the asynchronous nature allowing learning to be self-paced (Deng et al., 2020). However, MOOCs' use could be seen as simply allowing access to course material, and not improving learning (Flavin, 2016). Therefore, MOOCs have been recommended as a vehicle to support, not replace, in-person CPD in coaching (Cushion & Townsend, 2018).

Coaches are increasingly receptive to utilising online support mechanisms to enhance their learning experience (Leeder et al., 2021), with the COVID-19 pandemic accelerating this acceptance (Stoszkowski & Collins, 2022). Whilst the use of MOOCs for effective learning has been questioned, the use of asynchronous online learning as part of a blended learning programme shows more positive results in literature. For example, using Educational Psychology university students, blended online and face-to-face discussions help learners develop higher order andragogical skills, such as critical thinking skills, and improved the quality of written reflections (Szabo & Schwartz, 2011). Of note however, the relationship between student and the academic researcher in educational research raises questions as to a potential in bias and power imbalance (Ferguson et al., 2004). Glang et al., (2010) formulated an online educational programme targeted at youth sport coaches. The primary goal of the course was to cultivate practices related to sport concussion prevention and management. The researchers developed an online resource divided into three modules, each incorporating practical scenarios. Noteworthy discrepancies surfaced between the intervention and control groups across various measures. The authors contended that the outcomes evidenced the course's influence on improved comprehension. However, they acknowledged the study's inability to gauge the coaches' potential application of acquired skills and knowledge in practical, real-world settings. It is this link between online learning and on-field application that requires further thought. Referring to guidelines for digitally evaluating hands-on

abilities in sports medicine a tripartite framework was proposed (Hay et al., 2012). This model encompassed tutor exemplars serving as a benchmark for learners, self-produced videos by learners demonstrating practical skills followed by tutor evaluations, and a conclusive appraisal of practical skills through live video conferencing.

Despite the general paucity of research focusing on blended learning in coach education, initial results of pilot projects suggest that a blended approach is feasible and supportive of learning (Vohle, 2017). Yet additional research needs to explore the implementation of blended learning within the game, specifically with regards to the synergy between NGBs and higher education institutions (Leeder M., 2022).

2.4.6 Section summary

The development of coach education and CPD programmes must balance educational and training approaches and learning methodologies. Formal education, while providing structure and accreditation, often fails to cater to individual coaching contexts or leverage coaches' existing knowledge. Informal and non-formal methods, such as workshops and peer collaboration, align better with the dynamic and context-specific nature of coaching but often lack depth or standardisation. Effective CPD design should integrate experiential learning, acknowledge diverse preferences, and foster practical application. Social constructivist approaches, focusing on collaboration and individual coaches' context of practical application, have gained prominence. These methods emphasise co-creation of knowledge and reflection but face barriers such as ingrained attitudes and the influence of habitus. Coaches often filter new information through existing frameworks, potentially rejecting or misapplying novel concepts. Peer interactions can

support integration, but sport science knowledge remains undervalued compared to experiential learning.

Operational barriers, including cost, time constraints, and geographic inaccessibility, continue to hinder coach development. Institutional shortcomings, such as rigid, top-down course designs, limit real-world applicability and engagement. Coaches prefer context-specific, collaborative learning environments, highlighting the need for flexible, tailored programmes. However, blended learning offers promise by combining online tools and face-to-face instruction, enhancing flexibility and accessibility. Yet gaps remain in evaluating its practical application. Online tools, such as MOOCs and asynchronous learning platforms, improve access but require further integration with practical coaching contexts. Addressing these challenges demands innovative frameworks and stronger collaboration between NGBs and academia.

2.5 Chapter summery

The reviewed literature highlights significant gaps in research and practice within grassroots football coaching, particularly in the female game. While participation in female football continues to grow, injury prevention strategies tailored to adolescent female players remain underdeveloped. Existing research points to various injury risk factors, such as neuromuscular fatigue, joint laxity, and biomechanical factors, but these are often studied in isolation. The complex interplay of multiple risk factors, as outlined by Meeuwisse et al. (2007), requires further exploration to provide comprehensive and practical insights for coaches. Research into hormonal influences and flexibility is especially limited, underscoring the need for high-quality, longitudinal studies.

The use and efficacy of NSTs in grassroots settings is another area requiring attention as there is a dearth of literature investigating the knowledge or use of NSTs in an applied industry setting. While tools like the FMS and SLHD offer promise, their limitations in football-specific contexts and younger populations are evident. Current NSTs lack validation for adolescent female footballers and fail to consider the constraints faced by grassroots coaches, such as time, cost, and expertise. Developing sport-specific, validated tools that integrate practical, cost-effective components is essential for supporting injury prevention efforts.

Coach education and CPD programmes also exhibit critical shortcomings. Traditional, formal educational approaches often fail to address individual coaching contexts or foster meaningful engagement. Informal and non-formal methods, such as peer collaboration, better align with the dynamic nature of coaching but lack depth and standardisation. Barriers such as financial constraints, geographic inaccessibility, and rigid course designs further limit the effectiveness of coach education. While blended learning models offer flexibility and accessibility, their practical application in football coaching contexts remains under-researched.

Future research should prioritise the development of validated NSTs tailored to adolescent female footballers and innovative coach education frameworks. These should integrate sport-specific injury prevention strategies, promote experiential and collaborative learning, and address operational constraints, ensuring grassroots coaches are equipped to enhance player safety and performance effectively.

This research aims to investigate the current knowledge, confidence, perceived barriers, and facilitators experienced by youth grassroots coaches regarding the use of NSTs. Building on these

insights, it seeks to develop an evidence-based NST specifically designed for the female youth grassroots game. Additionally, the study will design an evidence-led and industry-aligned coach education session to guide the effective implementation of this NST. Finally, aiming to fill some of the gaps in the literature mentioned in the above chapter, the research will provide recommendations for future advancements in coach education related to NSTs, with a focus on enhancing their applicability and impact within the female youth grassroots football context.

Chapter 3: Coaches' current knowledge, perceptions, barriers and facilitators for NSTs

3.1 Introduction

There is currently no research investigating two aspects crucial to development of NSTs: (1) the knowledge, perceptions, and confidence levels of grassroots football coaches regarding the use of NSTs, and (2) the potential barriers and facilitators influencing its implementation within grassroots football settings. Moreover, there is a lack of research exploring how the perspectives of coaches working with adolescent female footballers are integrated into the development of bespoke CPD sessions designed specifically for grassroots coaching contexts. To address these gaps, this study employed a mixed-methods approach. Initially, a survey was designed and distributed to grassroots football coaches who work with adolescent players. This survey aimed to gather broad insights into their experiences and perspectives. Next, a series of semi-structured interviews were conducted, focusing specifically on coaches of female adolescent footballers. These interviews provided a deeper understanding of their unique challenges and views, offering nuanced insights that complement the survey findings. Finally, a co-production focus group ('focus group') was formed with coaches currently coaching female adolescent footballers in order to gain specific insight from coaches into the design of the resultant CPD session (see Figure 5).

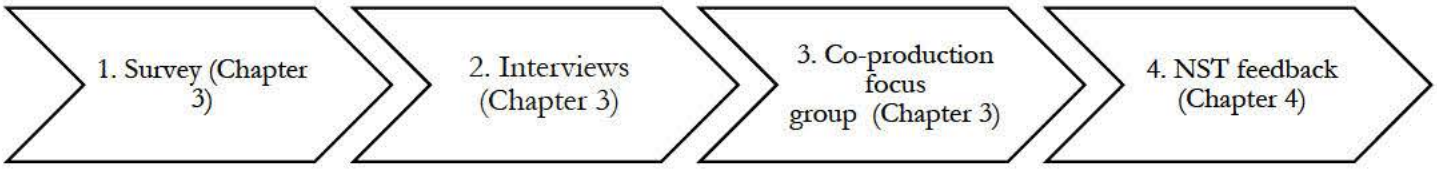


Figure 5. Process of research data collection

3.2 Methods

3.2.1 Recruitment

3.2.1.1 Survey recruitment

Participants were invited to complete the survey anonymously via a variety of dissemination methods. Grassroots football clubs in England were sent emails inviting coaches to complete the survey. Club email addresses were obtained from the Football Association's club search function (http://www.thefa.com/get-involved/player#fa-find-football) with over 1,500 emails being sent to individual grassroots clubs. Social media was also utilised to increase the number of respondents. A search was carried out on Facebook for community groups including the words "grassroots", "soccer" and/or "football". These groups had to be based in England and were usually associated with a geographic location i.e. "northwest". Posts on these groups invited group members to complete the survey. Additionally, participants were also contacted via LinkedIn and Twitter ('X') after manually searching for UK-based "grassroots football / football coach". The initial emails and social media posts were followed up after four weeks to increase the response rate.

To ensure both face and content validity, pilot testing of the survey was conducted by a small sample (n = 5) of football coaches, ranging from experienced regional coaches to local grassroots coaches. The views of the pilot testing cohort were collated and analysed, with minor changes being made to the survey prior to release.

3.2.1.2 Interview recruitment

Following closure of the survey, the same method documented above was conducted to recruit participants to undertake interview. Interviews were arranged with participants via e-mail (including the dissemination of the Informed Consent Form - Appendix 3).

Additional inclusion criteria were developed:

- Currently coaches (or very recent experience of coaching) female adolescent footballers at a grassroots level
- Have completed the above survey (as the survey was anonymous, this question was included as part of the Informed Consent Form)
- Were based in England

All interviews were conducted remotely via Microsoft Teams.

3.2.1.3 Co-production recruitment

All participants who were involved in the semi-structured interview were invited to take part in the focus group. The focus group date and time was arranged mutually with participants via e-mail (including the dissemination of the Informed Consent Form - Appendix 3). The additional inclusion criteria outlined for the Interview recruitment process was followed for focus group participants.

3.2.2 Survey development

The survey (Appendix 1) was designed and hosted using Jisc Online Surveys (https://www.onlinesurveys.ac.uk). Ethical approval was granted from the University of Gloucestershire Research Ethics Committee (Appendix 2). Informed consent was obtained from all respondents completing the survey. Participants did not receive a reward or benefit for completing the survey.

The survey consisted of 21 questions. Questions one to five related to the demographic and coaching experience of the respondents and were answerable via tick-box categories where respondents were asked to provide age, sex, their highest football coaching qualification, their

years of coaching experience and to highlight which age group(s) they currently coached. Questions six to 15 were adapted from a structure outlined by Donaldson et al., (2018) who sought to survey coaches' views regarding the barriers and facilitators to implementing a sport injury prevention programme. Glasgow's (1999) RE-AIM framework provides a framework to assess health interventions and questions in the current paper followed a similar RE-AIM structure as outlined by Donaldson et al., (2018). The RE-AIM framework (Glasgow et al., 1999) offers a structured approach to evaluate the impact of interventions across five dimensions: Reach, Effectiveness, Adoption, Implementation, and Maintenance. When applied to sports coach education sessions, it provides a comprehensive evaluation of their design, delivery, and outcomes. Reach assesses the extent to which the programme engages its target audience. This includes evaluating the number and diversity of coaches who participate and identifying barriers to involvement (Glasgow et al., 1999). Effectiveness examines the programme's impact, focusing on changes in coaching knowledge, behaviours, and subsequent effects on athletes (Donaldson et al., 2018). Measuring both intended benefits, such as improved coaching practices, and unintended consequences, such as resistance to new methods, is essential. Adoption evaluates the willingness of organisations and individual coaches to implement the programme. Factors like organisational culture and perceived utility influence this dimension (Glasgow et al., 2019). Implementation focuses on the fidelity and quality of delivery. Consistency, resource availability, and facilitator competence are critical for maintaining programme standards (Glasgow et al., 2019). Maintenance examines the sustainability of the programme and its long-term impact. Regular follow-ups can ensure the integration of learned practices into coaching routines (Glasgow et al., 1999).

Questions also consisted of a mixture of Likert scale questions (with responses "strongly agree", "agree", "not sure", "disagree", "strongly disagree") and ranking questions where respondents were required to rank certain attributes in order of their perceived importance/value (Table 1a and Table 1b). The survey was designed to answer the following research questions:

1. What is the current knowledge, perceptions and confidence levels of grassroots football coaches regarding the utilisation of a neuromuscular screening tool?
2. What are the potential barriers and facilitators regarding the implementation of a neuromuscular screening tool for use by grassroots football coaches?
3. What are the recommendations from current active coaches regarding the development of the NST and accompanying CPD session

To enhance the quality of information received via the survey, most questions were set to 'required', meaning that respondents had to provide an answer for a 'required' question before the online survey would let them proceed. This was not the case for some open-ended questions, such as question 16 "If there are any other facilitators that would help you implement a neuromuscular screening tool in your practice, please explain these below." The above mechanisms limited the number of surveys that needed to be discarded during the research process. The survey was live from 1st April 2022 to 1st April 2023. A copy of the survey can be seen in Appendix 1.

3.2.3 Interview development

Post survey, coaches were asked to undertake a qualitative interview lasting for approximately 20-30 minutes. The aim of the interviews was to gain greater depth of knowledge into the views of coaches, specifically, coaches who currently coach adolescent female grassroots footballers.

The interview was designed in a semi-structured manner, allowing the interviewer to prepare questions prior to interview, but also allowing the interviewer the flexibility to dissect responses and ask additional probing questions during the interview to gain further insight. This method of interview allows the researcher the opportunity to obtain high-quality qualitative data from participants (Seidman, 2019). Questions were designed related to the research questions previously

mentioned but were informed by the interviewer's past personal experience in football coaching as well as current research in this area (Marshall et al., 2021). As the order of the questions could influence the responses during interview (Lune & Berg, 2016), the questions were developed to follow a similar path, and were grouped into themes.

- Coaching background
- Coaching philosophy and knowledge of movement screening
- Potential need or use for movement screening
- Barriers / facilitators of movement screening
- Views on knowledge transfer / CPD activities.

A rehearsal interview was conducted with a grassroots coach of male adolescent footballers to identify limitations of the interview process. As a result of the rehearsal interview, a revision of the questions reduced their formal style, allowing for a greater conversational approach to be adopted during interview.

3.2.4 Focus group session development

The purpose of the focus group was to involve coaches actively working with female adolescent footballers at the grassroots level in shaping the development of the NST. This collaboration aimed to integrate their insights into the process, specifically addressing the barriers, limitations, and facilitators they had encountered within the current industry landscape.

The focus group was conducted online via MS Teams and recorded on both the platform and a smartphone as a safeguard against data loss. The session was facilitated by the researcher, who guided discussions across several key topics using an open-question format. This approach

encouraged participants to share their perspectives and engage in dialogue with one another. The topic areas were designed to expand on those posed during the survey and interview phases (phases one and two), enabling a more in-depth exploration of several critical aspects of NST development. Key topics included:

- Identifying specific areas of the body that the screening should prioritise.
- Session delivery (i.e. face-to-face, online, hybrid)
- In-session activities
- Materials and equipment for session
- Post-session activities and ongoing support
- Session timings
- Post-NST activities

An outline of the questions / discussion points is show in Table 2.

3.2.5 Analysis

Survey - Data was initially downloaded and organised using Microsoft Excel 365. Descriptive statistics were presented. The two open questions were analysed by identifying key words used (i.e. "We don't have enough *time"*). Thematic analysis, as described by Braun and Clarke, (2006) and which is used in the analysis of the interview (below), was not required due to the low number of words written by participants in each open answer.

Interview and focus group – sample sizes for interviews differ between researchers, with a suggested sample size of anywhere between five to 50 participants (Dworkin, 2012). Thematic saturation has been proposed as a method to determine sample sizes for qualitative interviews and has been defined as the point of which no new information is obtained by subsequent interviews (Dworkin,

2012; Weller et al., 2018). This study followed the recommendations of Buckley (2022) for determining thematic saturation in qualitative research.

An audio recording of the interview was undertaken using a smartphone. This was preferable to recording the interview on Microsoft Teams due to the ability of the audio recording device to assist with transcribing the interview. Immediately after the interview the audio recording and associated transcript was transferred from the smartphone onto a standalone desktop computer (i.e. not cloud storage), which was password protected. Participants were asked to confirm they agreed to partake in the interview at the start of the interview, which was documented via an audio recording. During the transcribing of the interview any names were anonymised (including the names of the coaches and the names of the clubs). A copy of the interview questions can be found in Appendix 4.

Interviews were fully transcribed verbatim and coded prior to undertaking a subsequent interview to determine an appropriate saturation point. There no was saturation point identified or required for the focus group

Thematic analysis is an often-used analytical method of qualitative research, allowing data to be analysed with appropriate contextualisation (Braun & Clarke, 2006). It allows data to be analysed by less-experienced qualitative researchers under an appropriate theoretical framework, while still following a robust methodological process (Braun & Clarke, 2006, p. 87). This study employed the framework set out by Braun & Clarke, (2006).

1. Data familiarisation - transcribing interviews, noting down initial ideas. Transcribed verbatim interviews were edited from the automatically generated transcript of the interviews by the smartphone. The interviewer edited the transcription by re-listening to

the interview and amending as necessary. Transcriptions were uploaded into NVivo Pro 12.6.1 (Lumivero, USA) for analysis for the below points.

2. Generating initial codes
3. Searching for themes
4. Determining core themes from the interview data

Table 1. Survey questions related to the RE-AIM structure and the research questions

Survey question no.	**Question topic**	**RE-AIM category**	**Research question**
1-5	Demographic questions – sex, age, highest coaching qualification, year' coaching, who coach (sex and age group),	Reach	NA
6	Coaches' previous use and knowledge of NSTs	Reach	1
7	Coaches' awareness of colleagues using NSTs	Reach	1
8-9	Perceptions of injury risk screening tools	Effectiveness / Adoption	1
10	Time needed to complete a NSTs	Implementation / Maintenance	2
11	Perceived benefits of NSTs	Effectiveness	1
12	Perceived barriers of NSTs	Reach / Adoption / Implementation	2
13	Perceived facilitators of NSTs	Reach / Adoption / Implementation	2
14	Confidence in use of NSTs	Implementation	1
15	Instructional requirements for the use of NSTs	Adoption / Maintenance	2
16	Open question - facilitators	Reach / Adoption / Implementation	NA

Table 2. Focus-group questions related to the RE-AIM structure and the research questions

Focus group question topic	RE-AIM category	Research question
Area(s) of the body participants want the NST to concentrate on	Effectiveness	3
Modality of session	Implementation	3
In-session activities	Implementation	3
Views on timings	Adoption / Implementation	3
Equipment needed (for CPD and NST sessions)	Implementation	3
Post-session activities / ongoing support needs	Maintenance	3
Post NST actions and signposting	Effectiveness / Maintenance	3

3.3 Results

3.3.1 Participants

A total of 111 online surveys were completed. A total of eight follow-up interviews were conducted post-survey. Two participants took part in the focus group. The response rate for the survey was low, with an approximate response rate of 5%. Due to the need to complete questions before the respondent could progress to subsequent questions on the survey, all 111 surveys were viewed as complete and included in analysis.

The demographics of the participants is shown in Table 3. The mean age of the participants was 45.1 ± 11 and 43.75 ± 10 years old for the survey and interviews and 37.5 years old for the focus group. For the survey, 101 participants (91%) were male, while nine participants (9%) were female. Of the participants who completed the interview, six (75%) were male, while two (25%) were female. One male and one female participants in the focus group. Both participants of the focus group held the UEFA C coaching qualification. The UEFA C coaching award was also the highest qualification held by most of the participants who completed both the survey and interview (68%

for survey, 75% for the interview) followed by the UEFA B coaching award (23% for survey, 25% for the interview). For the survey, one coach (0.9%) held a UEFA A award and three (3%) stated they were undertaking coaching qualifications at present. Their responses were still included in the analysis as they were currently undertaking active education while coaching regularly at a grassroots level. Years' coaching experience was evenly spread over the five categorised responses via the survey, with the majority of participants stating that they had been coaching over 10 years (n = 39, 35%), with the remaining participants stating that they had been coaching between 3-5 years (n = 27, 24%), 6-8 years (n = 23, 21%) or 0-2 years (n = 16, 14%). Only six participants (5%) stated that they had been coaching between 9-10 years. The interviewed participants as a cohort had less coaching experience. The focus group participants had between 3-5 years coaching experience. Most of the participants from the all interventions (survey, interview, focus group) coached U13-U16 (31% for survey, 88% for interview, 100% for focus group) or U10-U12 (26% for survey) age groups. Other coaches identified via the survey that they coached either U7-U9 (n = 21, 19%) or 17+ (n = 13, 12%) age groups. Of the 14 survey respondents (13%) who identified that they coached an "other" age group, further analysis showed that they coached a variety of age groups spanning across the categories, i.e. "all of the above", "U7 & U9 Girls, U17 Boys" and "U10 through U15".

Table 3. Demographic of respondents (n = 111 for survey, n = 8 for interview)

	Survey. n, (%)	**Interview. n, (%)**	**Focus**
n =	111	8	2
Age (years)	45.1 ± 11	43.75 ± 10	**37.5 ± 4**
Sex			
Male	101 (91%)	6 (75%)	1 (50%)
Female	10 (9%)	2 (25%)	1 (50%)
Highest coaching award			
UEFA C	68 (6%)	6 (75%)	2 (100%)
UEFA B	23 (2%)	2 (25%)	0
UEFA A	1 (0.9%)	0	0
Other	9 (8%)	0	0
Years' coaching experience			
0-2 years	16 (14%)	0	0
3-5 years	27 (24%)	4 (50%)	2 (100%)
6-8 years	23 (21%)	1 (13%)	0
9-10 years	6 (5%)	0	0
Over 10 years	39 (35%)	3 (38%)	0
Age groups coached			
U7-U9	21 (19%)	0	0
U10-U12	29 (26%)	1 (13%)	0
U13-U16	34 (31%)	7 (88%)	2 (100%)
17+ years	13 (12%)	0	0
Other	14 (13%)	0	0

3.3.2 Current knowledge, perceptions and confidence levels of grassroots football coaches regarding the utilisation of a neuromuscular screening tool

3.3.2.1 Coaches' current knowledge of NSTs (Reach)

Most coaches (n = 97, 87%) had not heard of a NST prior to completing the survey. Additionally, most coaches stated that they "never" (n = 50, 45%) saw, or were "not sure" (n = 47, 42%) that coaching colleagues use NSTs. Coaches that had previously heard of NSTs (n = 14, 13%) were invited to state which NST they were aware of. A total of 13% coaches (n = 14) from the survey respondents stated that they had previous awareness of NSTs. Given a list of popular NSTs, 20% (n = 7) of these subset of coaches selected that they were previously aware of the FMS, 14% (n = 5) of coaches had heard of the Athletic Ability Assessment and 11% (n = 4) of coaches had heard of the SLHD. Note – coaches could select as many NSTs that they had heard of from the list (Table 4).

Table 4. Coaches' awareness of specific NSTs

NST	N	%
Functional Movement Screen (FMS)	7	20
Athletic Ability Assessment	5	14
Single leg hop for distance (SLHD),	4	11
Tuck Jump Assessment	4	11
Single leg countermovement jump (SLCMJ)	3	9
Y-Balance	3	9
Landing Error Scoring System (LESS)	2	6
Other	2	6
Resistance Training Skills Battery	2	6
Star Balance,	2	6
The Drop Jump Screening Test (DJST),	1	3

Note – coaches could select as many NSTs that they were aware of.

To ascertain if coaches watched for AMC during sessions, via interviews coaches were asked what they were looking at from a coaching perspective generally during gameplay and training. Six interviewees did not mention that they were watching for AMC during their coaching activities, rather they watched for the enjoyment, effort and tactical / technical development of players:

> *"You're looking for the girls to be putting on board the things you've been talking about… Other things that are a big bugbear of mine is communication; the girls were quite shy and quite quiet, so were trying to get them to be more vocal. To me football is a game of communication, so as well as your skill level, if you are well organised, by talking to each other, you are going to be quite a good side. Most of our conversations at half time and after the game are around those sets of technical bits, communication, shouting each other, those sort of bits, rather than what the result is." (Participant 1).*

> *"The first thing is about giving 100%. The next thing is that they are enjoying it, if they don't want to be there then they shouldn't be there. And the last thing is that what we try and teach them during the week in training, you like to see every so often that comes out in a game. It is really pleasing when you have planned for something or train for something and see it actually come off in a game." (Participant 2)*

> *"Just the basics really, just for them to control and be able to pass the ball on the floor." (Participant 3)*

> *"If the players are comfortable on the ball, how is their first touch, their movement off the ball, their aggression dare I say it, but their intensity to be honest. That level of commitment." (Participant 4)*

> *"I just like all the girls to give 100% of themselves, I am very competitive but I don't want to force this on the girls too much." (Participant 6).*

"(I) really just look for the progression in players so that they are trying new things and new skills or if they were making certain mistakes or issues with certain skills but over the weeks and months those mistakes don't happen anymore. I'm also looking for if they seem to be enjoying it, and how they are tactically so from that I mean whether they start to make runs into space or whether they try and pass into space rather than just passing sideways to a friend that they always pass to." (Participant 7)

During interviews, there was only one participant who watched for changes in AMC with their players during their coaching practise:

"There is a lot of things, especially with girls at this age as they are experiencing periods and all of the changes that happens in girls can make their bodies do things that they don't think that they should be doing so, for example, joints become floppy and loose when they are menstruating, so I am always looking at their knees and ankles..." (Participant 5).

To further investigate coaches' awareness of movement screening in general, the interviewer prompted the coaches, this time specifically asking if the coach watched for differing movement competencies etc. Once prompted, more coaches outlined that they did (potentially subconsciously) watch how their players moved unrelated to performance (i.e. speed) or the tactical aspects of the game:

"Definitely, we have a few players who run a bit strange as it is." (Participant 2)

"I can tell when certain players are fatigued in their movements." (Participant 4)

"One of our strikers, last year especially, she more than anyone else had a growth spurt. She became very gangly so when she was running it was like her legs and arms were going everywhere." (Participant 8)

However, other coaches related AMC back to performance (i.e. speed) rather than the quality of movement:

> *"A girl that used to be, she was never a great footballer, but she was very influential because she was tall and quick until 9, 10 or 11, and suddenly when you get to u12's and people are catching her up, then she's not having an impact because she's not quicker and she's not taller." (Participant 3)*

Whereas other coaches stated they do not watch for the quality of AMC:

> *"For some of them generally it's just that you need to move! To be honest, not really with running as such." (Participant 1)*

When directly asked if they are heard of movement screening (NSTs), no coach highlighted that they had:

> *"No, I've ever done that or even thought about it. I've never seen it being done." (Participant 5)*

> *"I don't really know what movement screening is or how we do it." (Participant 7)*

3.3.2.2 Perceptions of NSTs (Effectiveness / Adoption)

Most coaches had a positive perception of the use of a NST, with 74% (n = 82) 'agreeing' or 'strongly agreeing' that the use of a NST would be beneficial for their players. Moreover, only 3% (n = 3) of coaches 'disagreed' regarding the benefit of a NST, with no coaches 'strongly disagreeing' (Figure 6).

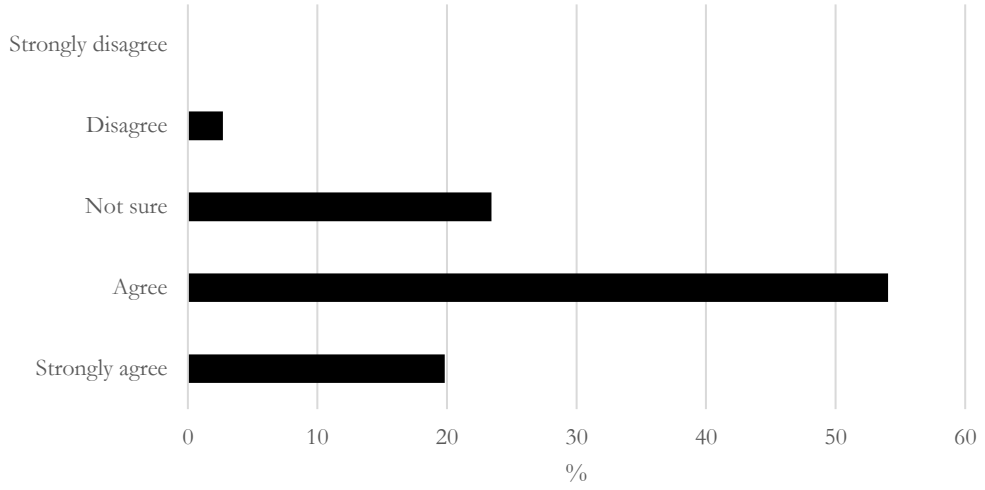


Figure 6. Perceptions of survey participants about the potential benefits of using NSTs with their players

A total of 71% (n = 79) of coaches 'disagreed' or 'strongly disagreed' with the statement that completing a NST with their players would be a waste of coaching time. In contrast, 9% (n = 10) of coaches 'agreed' or 'strongly agreed' with that statement (Figure 7).

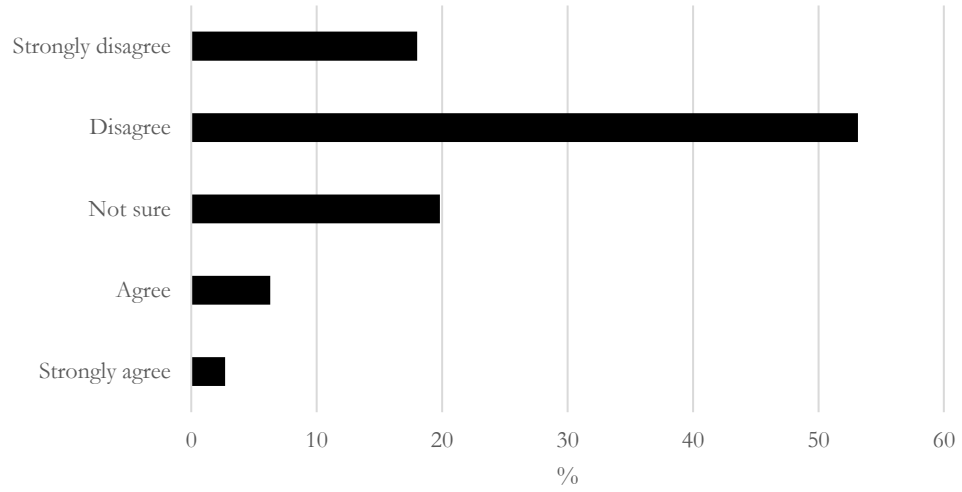


Figure 7. Survey participants' views on whether completing an NST with players was a waste of time or less important than other training priorities

3.3.2.3 Perceived benefits of NSTs (Effectiveness)

There were 60% (n = 67) of coaches who ranked the biggest potential benefit of a NST as the ability to help reduce injury prevalence/act as an injury screening tool, followed by using a NST to identify players who are not moving mechanically correctly (20% ranked this 2nd most important). The lowest ranked benefits of using a NST were fitness testing (47% of coaches ranked this 5th) and improving performance (39% of coaches ranked this 4th). (Table 5)

Table 5. Coaches' ranking of perceived benefits of using an NST

Rank	Perceived benefits of NST	%
1	Help reduce injury/injury screening	60
2	Help identify those who are not moving correctly	42
3	Improve performance	32
4	Help with exercise prescription	35
5	Fitness testing	47

Note - % shown as the majority % of coaches who ranked that specific perceived benefit as #1-5

All coaches that were interviewed perceived that a NST would be beneficial to be used within their coaching practise. There were subtle differences between what coaches believed the main use of a NST would be, with some coaches suggesting it should be used for injury risk identification:

> *"I think it would be good to use at a younger age, but I think it would be more critical as they get older due to more injuries." (Participant 2)*

> *"Because a lot of the time, they may end up injured themselves or end up injuring someone else because of this awkwardness [poor movement mechanics]. I think we would see far less injuries if this type of thing was incorporated more." (Participant 3)*

"I think it would be very useful because, especially for the girls who are around about 14, adolescence going upwards, I say starting to develop a little bit more, you could start to see if they stepped down [from the box example] how their knees are functioning, whether they do subconscious movements. I think it would be important because you might then be able to help them with certain mechanics that will help improve their mobility." (Participant 4)

"I suppose it might link to injury, so if they are not doing what they should do in terms of moving right then they might be more likely to be injured. So for me again it's back to that well-being type of approach rather than anything to do with performance." (Participant 7)

Coaches also thought that NSTs could be of benefit to help monitor player development:

"I think as an overall principle it is a good idea as you can use it to assess a player like you would a fitness test. You see how far along they are with something, so you can see progress." (Participant 5)

"I mean it would be good to see if you could almost quantify or identify when a player might be going through those issues with coordination." (Participant 7)

Coaches also identified pitfalls of using a NST to highlight injury risk or as a selection tool:

"You would probably have to sell it as something that would enhance your players rather than injury prevention, because otherwise some may say "my players don't get injured". (Participant 4)

"We wouldn't use it to select a player to play a game" (Participant 7)

Finally, one coach suggested that NSTs would help male coaches of female players develop a greater understanding of the differences between the male and female bodies:

> *"I think this is a brilliant idea and I think it would be really beneficial to a lot of players and teams especially in our club. I think there would be a lot of benefit to it as it might help breakdown that barrier a little bit with male coaches and female players because they can understand the female body a little bit more then what they may actually understand at the moment." (Participant 5)*

3.3.2.4 Confidence levels of using a NST (Implementation)

Most coaches (n = 21 + 49, 63%) suggested that they would be confident using NSTs with their players after instruction (19% selecting 'very confident', 44% selecting 'confident'). Only 9% of coaches stated that they would not be confident using NSTs with their players after instruction (6% selecting 'unconfident', 3% selecting 'very unconfident'). 28% (n = 31) of coaches were 'not sure' if they would be confident using NSTs with their players after instruction (Figure 8).

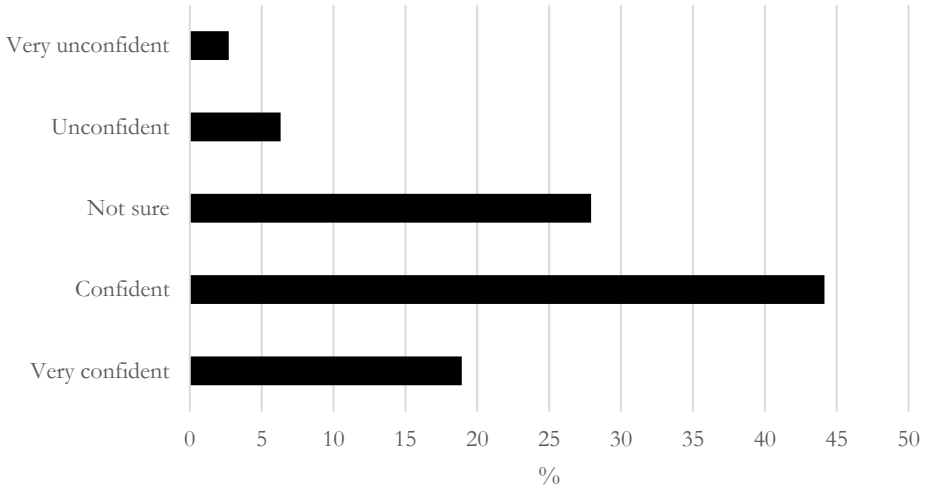


Figure 8. Survey participants' confidence in correctly completing an NST with players after CPD

Via interviews, coaches were unable to state that they were confident in the potential use of NSTs. As detailed above, this was due to their general lack of awareness of NSTs coupled with the lack of any training on NST use.

> *"it's an interesting thing about your own confidence in your ability to assess effectively. I think that is important. One of the courses that you do [as a coach] is first aid in sport, and everybody that does it I think finds it really interesting, and it is fine watching the videos as it is now online, but it's fine watching a video of Bob who has broken his leg, or someone has collapsed and you put them into the recovery position… my own view is that, that is all great in theory, and I have done and passed the assessment, but I have not actually had to do it myself. I think it could be the same with these sort of activities and assessments; having that confidence to assess yourself and be confident that your assessment is in the right ball park and accurate." (Participant 1)*

> *"The obvious thing is knowing what is right and what is wrong. For example, if we are talking about someone dropping from a box and they land, you need to know what the knees should do, what they should look like. For me, I'd need to know what the natural position should be". (Participant 2)*

3.3.3 Barriers to implementing NSTs (Reach / Adoption / Implementation)

Lack of knowledge was, by far, the biggest barrier noted, with 71% (n = 79) of coaches ranking this as the biggest barrier. The other largest barrier was the lack of facilities (n = 37, 33% ranked this 2nd). Lack of time was ranked the 3rd biggest barrier by 30% of coaches (n = 33), followed by a lack of confidence in performing the NST correctly (n = 23, 21% ranking this barrier 4th). See Table 6.

Coaches ranked lack of personal buy-in as the least important barrier (n = 56, 50% ranked this 7th), followed by lack of buy-in from the club (n = 36, 32% ranked this 6th). Coaches believed that lack of buy-in from players was the 5th most important barrier to implementation (n = 37, 33%).

Table 6. Coaches' ranking of perceived barrier to using an NST.

Rank	Perceived barrier to NST Reach / Adoption / Implementation	%
1	Lack of knowledge/education about NSTs	71
2	Lack of facilities	33
3	Lack of time	30
4	Lack of confidence in own performance	21
5	Lack of buy-in from players	33
6	Lack of buy-in from club	32
7	Lack of personal buy-in	50

Note - % shown as the majority % of coaches who ranked that specific perceived benefit as #1-7

Differing from the results of the survey, when questioned about the potential barriers to NST adoption and implementation, during interviews participants noted that time was the biggest factor:

> *"Time - we only train once a week for an hour. I mentioned earlier about having a limited time with the girls. We have an hour a week, but we do train virtually every week of the year. Even if we only have a small group of them, we will still do something with them." (Participant 1)*

> *"Time, time is a main one because we don't get a lot of time with them. Because you know, when they come training straight away they are asking you if they are going to have a game, so time is the biggest thing. But if you start them doing this when they're younger than they probably don't know any different and they just think it would be part of the training." (Participant 3)*

"Time." (Participant 4)

"I'm there and I have an assistant coach, but the two of us have to manage a squad of 18 and trying to manage the individuals while they are doing it for enough time to make that assessment meaningful is a difficulty as well." (Participant 5)

"Time is probably the biggest barrier for whatever we do with the girls. We have an hour with the girls every week, so we need to try and maximise that time that is both fun and helps improve them as players. So if we have to do this movement screening all the time, then we might have to take it out of some of the game time which is ultimately the reason the players want to come and play for us. So trying to do movement screening quickly or less frequently would be beneficial." (Participant 7)

"The access I have with the team for winter training is 55 minutes a week, and then a few minutes you may have before and after games. I think from what you are saying I don't think that equipment would be much of a barrier, because, I don't know if you're talking about slow motion filming, but we could do that quite easily. So I think that time would be the biggest barrier." (Participant 8)

Consistent with the results of the survey, lack of available facilities and equipment was highlighted as a limiting factor for NST adoption / implementation:

"Trying to get good facilities that are affordable is becoming harder and harder." (Participant 1)

"So for me I only have an hour training session a week, the facilities, trying to get more than that is just impossible, it is hard enough just to get the hour slot." (Participant 5)

"Equipment would be another thing. In your example you talked about dropping down from a box which I suppose we would be able to do but if you need proper equipment like weights or something, that'd be a bit of a barrier, as sometimes we even struggle getting enough cones and balls!" (Participant 7)

The results from the interview differ from the survey, where 'lack of knowledge' was highlighted as the largest barrier. However, in interviews, coaches did acknowledge that lack of knowledge was also an important barrier to NST implementation:

"Lack of knowledge was the main limiting factor." (Participant 2)

"The danger is that my opinion might be different to someone else's, it is very similar to do an assessment for someone doing a qualification as someone might say they're not quite there yet and someone else says that they are ready." (Participant 5)

Lack of buy-in from players was also noted as a potential barrier to NST adoption / implementation:

"One of the biggest barriers could be, depending on how these are structured, is … getting buy in from the players as to why they should engage with this sort of thing. Because they like to be doing ball work and playing football, and we as a club have the ethos of wanting to get them involved with the ball." (Participant 1)

However, absent from the survey, coaches during interview highlighted that parental buy-in was significant:

"My slight worry would be if we flag up potential problems to the players and to the parents and we don't have a solution, does that worry people and think that we shouldn't be playing football because of the risk." (Participant 1)

"For me personally it would be if you're running it past the parents on that particular day… I think it would be quite easy for the parents to think oh he's only just done a 30-minute session with someone about this, he's coming back and trying to change the world in relation to his training plan. So it is having a buying from the collective." (Participant 6)

"But we need to make sure that this is communicated to the players and the parents so they don't think that we're doing something that is going to harm them… I suppose it's just like we're doing a slightly different warm up in a training session, that is all." (Participant 7)

However, these points regarding both player and parental buy-in often relate back to perceived lack of knowledge or expertise on behalf of the coach:

"I think the kids would go with whatever you wanted them to do, they would be quite happy… It would be when you were giving them feedback that the parents may start asking questions such as "what do you know about knees", and then questions would be coming back." (Participant 6)

Lack of knowledge is also assumed as a limiting factor in NST Reach / Adoption / Implementation, in relation to the results of screening:

"There's no point highlighting if someone is moving differently if there's nothing we can do about it… I mean, does that just mean that we can't play that person but if that is happening for months then that's

not fair is it? It's not just about doing the actions but it's about what happens after the actions." (Participant 7)

Additionally, a female coach interviewed also highlighted the perceived lack of male coaches' understanding of the female body:

"I do think that there is a bit of a barrier there [from male coaches], maybe there is an expectation that females should be able to do things that boys can do and coaches can talk to people exactly the same… I think they speak to boys differently when they coach than they do to females… maybe girls can be a bit more sensitive?" (Participant 5)

Although lack of time was generally highlighted as the main barrier to NST Reach / Adoption / Implementation, lack of knowledge about NSTs (i.e. coaches' perceived lack of knowledge from players and parents, lack of knowledge of NST aftercare, and lack of knowledge of the female body by male coaches) is directly and indirectly outlined as a significant barrier to NST implementation.

3.3.4 Perceived facilitators of NSTs (Reach / Adoption / Implementation)

Table 7 shows that coaches ranked support and education as the most important facilitator for the Reach / Adoption / Implementation of NSTs (n = 56, 50% ranked this 1st), followed by buy-in from their club (n = 27, 24% ranked this 1st). These results were mirrored in the choice of the second most important facilitator (n = 29, 26% ranked education 2nd; n = 29, 24% ranked club buy-in 2nd). Equipment was the third most important facilitator according to coaches (n = 29, 26% of coaches ranked this 3rd). The reduction of tactical game play/training time to complete the NST was rated as the least important facilitator (n = 33, 30% of coaches ranked this 6th and 5th). On a

par with this, the lack of training space was also ranked low in terms of implementation facilitators (n = 29, 26% of coaches ranking this 6th, and n = 27, 25% of coaches ranking this 5th).

Table 7. Coaches' ranking of perceived facilitators for using a NST

Rank	Perceived facilitators to NST Reach / Adoption / Implementation	%
1	Support and education from the FA	50
2	Buy-in/support from the club	24
3	Better facilities (equipment)	26
4	Better facilities (space)	22
5	Extended training time	21
6	A reduction in tactical/game play to complete the NST	30

Note - % shown as the majority % of coaches who ranked that specific perceived benefit as #1-6

Out of the coaches, 15% (n = 17) added an additional facilitator(s), as noted through open questioning (Figure 9):



Figure 9. Facilitators noted via analysis of open questions in survey. Responses included Experts (4), Mentors (4), Evidence (4), CPD (3), Videos (2), More coaches (2), Mobile app (1), Fun (1), Facilities (1).

Facilitators noted during interview linked with the barriers highlighted by coaches. Knowledge, in the form of training (CPD), was the main facilitator required to adopt and implement NSTs within the coaches' club:

"I think a toolkit, such as when I'm planning a coaching session I will use the FA website or go onto YouTube. I have a look at what resource is and information is there. So, having a bank of resources and activities that you could do is quite important." (Participant 1)

"So I think for me the biggest thing is more the understanding of it, what you are looking for." (Participant 2)

"A clear plan of what needs to be done. If I was given something like this is a coaching plan of how you do this well obviously, on a Thursday or Friday night I'm looking for drills to do for coaching so if someone has put something down and said this is what you can do tomorrow then it makes a job a lot easier, obviously." (Participant 3)

"So knowledge is everything, whether it is someone coming into oversee you for a certain time, if you could get someone alongside the coach who has more experience and knew what they were talking about. They may come to a couple of sessions and then you may carry on from there, once you've had the grounding then." (Participant 6)

"So some form of training would also be needed to roll out movement screening in the club. (Participant 7)

The only other facilitators noted during the interviews was buy-in from the club, players and parents:

"I think once it is developed and embedded in the club… I think it is important that it is done at a club level and not at a team level." (Participant 5)

"I suppose also getting the OK from the players and the parents." (Participant 7)

"I think it is getting that agreement from the parents. Getting the agreement from the committee as well would be a good thing to start doing. They would need to see the benefits as well, what would be the benefits of doing this and how could we realise them." (Participant 8)

3.3.4.1 Time needed to conduct NSTs (Implementation)

There are varied views regarding the length of time that coaches believe a NST should take (see Figure 10), with most coaches believing a NST should take between 6-10 mins (n = 38, 34%), followed by 11-20 mins and 21-30 mins (23% and 19% respectively).

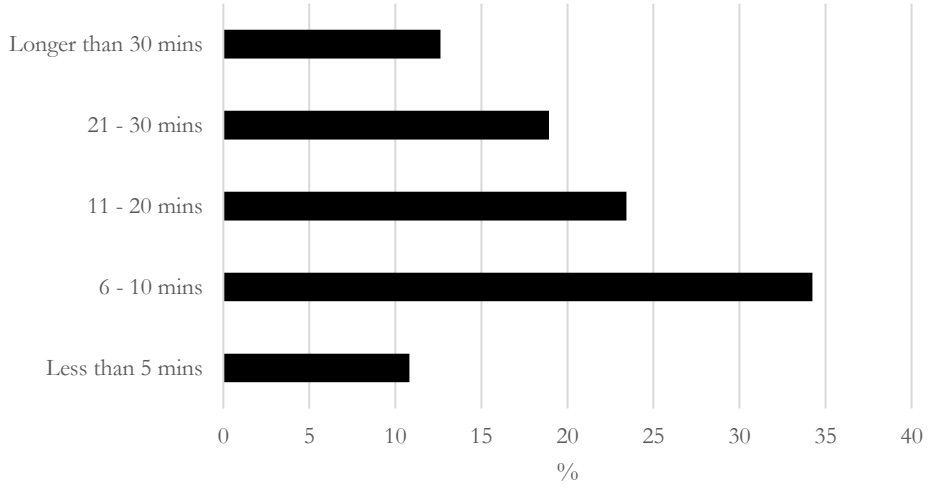


Figure 10. Survey participants' views on the ideal duration of NSTs

3.3.4.2 Instructional requirements for the use of NSTs (Adoption / Maintenance).

Most coaches viewed 'Face-to face-workshop' educational workshops as the most appropriate delivery style of NST training (n = 80, 71% of coaches ranked this item 1st). The second most popular number one rank was 'Live online workshop' (n = 12, 11%). 'Live online workshops' was ranked second by most coaches (n = 42, 38% of coaches ranked this item 2nd) followed by

asynchronous online courses (n = 35, 33% of coaches ranked this item 2nd, with 44% of coaches ranking this item 3rd). Coaches did not believe that field-based documents (NST user guides etc.) would help them conduct NSTs, with 49% (n = 54) of coaches ranking this the least popular option (Table 8).

Table 8. Coaches' views on best NST CPD modality

Rank	CPD modality	%
1	Face-to face-workshop	72
2	Live online workshop (via Team, Skype, Zoom or similar)	38
3	Online course that you work through at your own pace	45
4	User guide/manual that you can take onto the training pitch with you	49

Note - % shown as the majority % of coaches who ranked that specific CPD modality as #1-4.

As mentioned previously, during interviews, coaches cited lack of knowledge as a major barrier and the development of new knowledge a key facilitator for the implementation of NSTs within their clubs. These answers were followed up by a question of how they perceive that they would gain this knowledge. Most coaches agreed with the results of the survey, in that they believed face-to-face training was the most suitable for themselves.

> *"I'm that type of person, I like being hands on, so that [face-to-face training], on reflection, would probably be more effective." (Participant 1)*

> *"I think that there is nothing better than an actual face-to face-course." (Participant 2)*

> *"I personally like face-to-face." (Participant 4)*

> *"My preference is face-to-face as I like seeing. If I can get there and see it practically then I like to do that rather than seeing technical information online." (Participant 6)*

"I think I would learn better if there was face-to-face training." (Participant 7)

"I suppose it would depend on the nature of the training and the information that is trying to be put across - If it is better to have that hands on experience and if you are showing something like a model of a knee or whatever - a bit like first aid training for example when you have to get the dummies out. It is much better than sitting through it online as it is better to do this visually then trying to describe it." (Participant 8)

Coaches also noted some negative experiences / drawbacks to online CPD:

We have done a few online courses such as the introduction to first aid, and you are sitting there doing the course… It is quite easy to switch off, so I'm not a fan of those sort of things, so certainly face-to-face." (Participant 4)

"I have done some safeguarding training and a couple of learning pathway FA courses. I don't find them very good at all if I am honest, I think that they're over simplistic, I think that they are easy to take shortcuts on and whiz through." (Participant 8)

But many coaches highlight some positive experiences of a hybrid approach to CPD and /or the use of online tools to supplement their learning:

"I would like some backup with some online stuff. Maybe someone you could go to or maybe something like a forum or a chat group where other coaches may post things saying I have a player doing this, what do people think? But for me the critical thing would be a face-to-face session. You take more in than just sitting online going through something." (Participant 2)

"I use videos all the time to get my training stuff so that would work for me. And if it is a video then you can show the players as well, you can put it on your phone and show them what you want them to do so that kind of makes sense as well." (Participant 3)

"I mean, probably like a lot of people, I did a fair bit of online learning during the pandemic. I like some of it, but not most of it. The bits I liked was when they had good resources such as a YouTube or something that you could watch multiple times, or that they had the same kind of coaching drill filmed from different angles. Some of the other stuff that I did they had questions throughout the online training but the questions were so basic that you didn't really need to read any of the training to answer correctly. They probably did it so you would pass. I'm thinking safeguarding training as one of the examples." (Participant 7)

Of the challenges to CPD, coaches highlighted similar barriers to the implementation of NSTs, namely time and buy-in:

"During COVID we did coaches workshops online, but the participation level varied depending on what the topic was. More game-related topics seemed to get more interest… the attacking ones you'd get a lot more. Session planning got a lot more, but when more sessions were built on that, certain coaches thought they'd got enough from the first session so didn't want to come to the later sessions." (Participant 4)

"We don't get that many who want to participate because they don't think it is that relevant to their own team. So I would say, short, say 2hr, over a period of time, depending on what sort of knowledge they need to get or what sort of knowledge you need to give them. If it's a whole day, I don't think you would get a lot of coaches who would volunteer [for training]." (Participant 4)

"[some CPD I have done] is generally group orientated and you get about 3 to 30 individuals, I've done some when there is about 60 individuals, but that generally is when there is a more experienced person there such as the head of English football who led that." (Participant 6)

"It is always challenging finding a date and a time when everyone is free at the same time." (Participant 8)

3.3.4.3 Focus group results

3.3.4.3.1 Area(s) of the body participants want the NST to concentrate on

Both participants suggested that the lower limbs, specifically the legs, would be the preferred area of focus for the final NST.

"For me, definitely the lower legs." (Focus Group Participant 1 – FG1)

"Yeah, me too, that's where most of the injuries occur from what I can tell." (Focus Group Participant 2 – FG2).

This result is important as during the interview, coaches rarely disclosed to watching movement mechanics of players and only made passing reference to the lower limbs (i.e.… *"so when she was running it was like her legs and arms were going everywhere.", Participant 8*).

3.3.4.3.2 Modality of session

Both focus group participants valued a face-to-face CPD session, especially compared to online-only training.

"I always find that face-to-face CPD sessions are better." (FG1)

"I always find face-to-face better too. I did some online training during lockdown, but it was pretty poor to be honest with you." (FG2)

The views of the focus group were consistent with the views of participants who completed the survey (where 71% of coaches ranked this item 1st) and interviews *("I think that there is nothing better than an actual face-to face-course." [Participant 2], "I personally like face-to-face." [Participant 4]).* Of note, focus group participants suggested that some online-only training suffered due to lack of required engagement from participants *("It was too long and dull… questions were just pointless" FG2)* with FG1 being concerned that online training is less suitable for learning practical skills *("I'm not sure that an online session for a practical thing would be the best way forward").* Of additional note, FG1 shared that one benefit of face-to-face CPD was the ability to engage with peers *("you do get time to catch up with other coaches and see what they think about the session, or what they are doing at their clubs").*

When a hybrid approach was suggested by the focus group facilitator, there was broad but tentative agreement that this approach maybe agreeable, which is consistent with views presented during the interviews (Participant 3 and Participant 7). FG1 suggested that a hybrid approach may improve the time efficiency of the NST CPD session (with time being the 3rd biggest barrier to conducting an NST).

"Well, I assume that this might cut down a bit of time somehow." (FG1)

FG2 suggested the hybrid approach would allow increased focus on on-field activity as well as more flexibility for the participant coach to undertake the training in a time to suit their needs.

"… if you send (coaches) some videos of what's going to happen, then there might be less explaining and standing around on the day." (FG2)

In a hybrid approach, FG2 cautioned the use of online material if not clearly linked to on-field activities.

> *"…it needs to be clear to coaches how this online bit links with the overall training session and why they need to do it before the face-to-face session." (FG2)*

3.3.4.3.3 In-session activities

Consistent with the earlier point, both FG1 and FG2 also suggest time within the CPD session where participant coaches can interact with peers.

> *"I'd probably like a chance to speak to other coaches… to see how they might do the screens…" (FG1)*

> *"… I'd probably like a chance to speak to other coaches and kind of see how they're going with it, so like speak to a coach of another club to see how they might do the screens… would they do them once a week or once a month, do they have more time than we do, or something like that." (FG2)*

Both participants saw the value of practising the practical element during the CPD sessions.

> *"well of course I think we as coaches need to be able to practise the scoring systems that there will be for each of the screens." (FG1)*

> *"So activities where you've got a mentor or an expert there and they can score the screen and then you can score the screen and you can see if there are any differences." (FG2)*

3.3.4.3.4 Views on timings

Both participants highlighted time as a barrier to all coaching activities including the CPD session, which has been consistently reported in previous interactions (survey and interviews). Of note,

FG1 suggested that a hybrid session may help the CPD session become more time-efficient and effective overall by allowing coaches to individually pause/rewatch online resources.

> *"Maybe that's why an online session might be better to some degree, as you're able to pause the video, look at things in detail or slow motion, and make notes." (FG1)*

FG1 suggested that the timing need to conduct the NST is also important for player management.

> *"…so the players aren't hanging around getting bored or cold or messing around." (FG2)*

FG2 does suggested specific timing for the CPD session, although they admit this value was presented with little foresight.

> *"I'd say an hour max for the face-to-face session, although I might just be saying that as that's what we are used to!...Maybe 30 mins for the online…, but again… just a bit of guess work." (FG2)*

The focus group did not disclose a specific view on how long it should take coaches to conduct an NST. However, this opinion was gathered during the survey, where 34% of coaches (n = 38) advised that the NST should take between 6-10mins to conduct. Although the most popular response, that meant that 54.9% of coaches (n = 61) suggested that the NST should take over 10 mins.

3.3.4.3.5 Equipment needed (for CPD and NST sessions)

Both participants stressed the need for minimal scoring equipment for the NST (i.e., a note pad etc) or a scoring tool that was weather-proof .

> *"I would say minimal material needed to score the sessions. Maybe some way (of) recording them on a phone." (FG2)*

"I agree with (name) about having some form of waterproof scoring system." (FG1).

Participants emphasised the need for a lack of equipment to conduct the NST, and, as such, also a reduced equipment need to deliver the CPD session itself.

"then we also need to make sure that the screens themselves don't require a lot of equipment, and again, yeah, I suppose that also means that the training session we do doesn't require a lot of equipment." (FG1).

The hybrid session modality was also highlighted as a method to reduce equipment need

"The online session means you can make notes at home and keep those notes as a reference." (FG1).

The use of smartphones to record screens was seen as a possibility, if used correctly

"we have all got phones, so (I) suppose… We'd probably have to talk to parents about what we are doing with the recordings..." (FG2).

The use of smartphones was promoted during the interview phase (Participant 8). Consistent with the views of the focus group, the need to limit required equipment was stressed during interviews (Participant 5 and Participant 7). Equipment availability was also noted (via the survey) as the third most important facilitator for NST implementation (Chapter 3).

3.3.4.3.6 Post-session activities / ongoing support needs

Time is continually reported as a major barrier to CPD and NST implementation. When discussing post-session activities, both focus group participants suggested that they didn't believe that there

would be a need for significant post-session activities. Moreover, the hybrid approach was, again, suggested as a possible time-saver.

> *"We've talked about having it (the hybrid session) before the face-to-face session in order to make better use of the time on the field. If that's how the whole CPD session ends up then I don't think we really need to do a lot of post session activities." (FG2)*

> *"I wouldn't hope for a lot of post training session activities, like homework." (FG1)*

FG1 raised the possibility of a mentoring system (or other ongoing support) post completion of the NST CPD session.

> *"I don't know whether we have access to… a mentor… Or maybe some form of Facebook group." (FG1).*

Mentor use was not consistently mentioned during the previous survey or interview phases, with only 3% (n = 4) of coaches suggesting the need of a mentor in the additional comments section of the survey (Chapter 3, Figure. 9).

3.3.4.3.7 Post NST actions and signposting

The need for a post-NST signposting process was heavily emphasised by both focus group participants.

> *"This is probably the big one for me." (FG2).*

Without this signposting, the focus group participants suggested that there would be little use in conducting the NST in the first place.

> *"we can't just do the screens and then kind of go thank you very much" (FG2).*

The need for time-efficient signposting recommendations where the coach does not conduct the resultant NST actions with the players was recommended.

> *"So we can't do all the screening which is going to take time, and then once we get specific recommendations and we have to spend more time doing those recommendations within our training session such as like a longer warm up as we just don't have time." (FG1).*

The need for these signposting recommendations to be separate an independent from the current knowledge of the coach was also suggested and that the signposting recommendations were completed away from the normal football training session

> *"I'm not a fitness expert or physio or anything so I wouldn't really know what to do after this." (FG2)*

> *"It would be great if a player scores a certain score on a screen… we can give her a help sheet or something that they can go away and complete and that will help them improve on that specific screen." (FG1).*

3.4 Discussion

The purpose of this study was to explore the knowledge and confidence of youth grassroots football coaches in using neuromuscular movement screens. Additionally, the study sought to explore the barriers and facilitators behind the implementation of NSTs within the youth grassroots football game. The main results of the study found that grassroots coaches lack knowledge of NSTs but would be confident and willing to implement them, especially if NSTs help prevent player injuries. Coaches identified limited knowledge and time as key barriers and viewed education and training as crucial facilitators.

3.4.1 Coaches' current knowledge of NSTs (Reach)

The results from the survey show that coaches of youth grassroots football have limited knowledge or awareness of NSTs, either from their own practise or witnessing a NST being delivered by their coaching peers. These views were shared via interview from coaches specific to the female game as only one coach suggested they looked for movement quality during their regular coaching practise. As there is no research investigating the reach (knowledge and awareness) of NSTs used within any sport, comparisons need to be made to similar initiatives, such as injury prevention exercise programmes (IPEPs). The lack of reach of NSTs in our study is not surprising, especially given a lack of awareness of the 11+ among coaches, which is a FIFA-driven IPEP (Donaldson et al., 2018). Consistent with research from O'Brien and Finch (2016), 50% of grassroots coaches had not heard of the 11+, despite promotion from the coaches' NGB - Football Australia (Donaldson et al., 2018). Moreover, only 19% of youth grassroots coaches of differing nationalities reported having knowledge of injury prevention prior to an educational workshop (De Ste Croix et al., 2020). This lack of knowledge among grassroots coaches should not be surprising given that NGB coach education programmes within youth football focus on the improvement of technical skills (passing, dribbling etc) rather than movement competences (Duncan et al., 2022). Similar research suggests the same IPEP has increased reach (knowledge and awareness) in other nations, with Junge et al., (2011) finding that 80% of amateur coaches in Switzerland were aware of the 11+. These examples demonstrate that to increase the reach (knowledge and awareness) of NSTs within youth grassroots football, buy-in from the NGB is of paramount importance (Martindale & Nash, 2013).

3.4.2 Perceptions of NSTs (Effectiveness / Adoption)

Despite limited knowledge of NSTs, it appears that grassroots coaches may have an appetite for the adoption of NSTs. There were 74% of coaches that had a positive response (agree/strongly

agree) when asked about their perception of the overall benefit of NSTs, with only 3% providing a negative response (disagree/strongly disagree). Interviews also suggested that coaches may be reluctant to adopt NST practises if they have personally not experienced injury to players in their coaching practise. There is limited literature investigating coaches' perceptions of the benefits of NSTs or IPEPs. In the present study, most coaches (60%) believed the main benefit of a NST would be to help reduce injury prevalence/act as an injury screening tool. This finding is unsurprising given that De Ste Croix et al., (2020) found that 100% of youth grassroots football coaches maintain that injury prevention is vital for youth athletes. Moreover, when investigating coaches' perceptions of general movement competences, there was widespread acceptance among coaches (96%) that improving movement competencies was important for sport- and health-related reasons (Duncan et al., 2022). However, there is a poor association between injury prevention knowledge and IPEP adoption, suggesting that even if coaches believed a NST would aid injury prevention interventions, this knowledge may not translate into adoption (McKay et al., 2016).

The use of IPEP's may be age-group dependent, with a relationship between age group coached and the use of IPEPs being reported (Morgan et al., 2018). This suggests that coaches of older age groups (U15–U19) were potentially more aware of the need of IPEPs over coaches of younger age groups (U9–U14) due to the increased injury risk during adolescence, especially in female participants (Davidson & McLean, 2016; Myer et al., 2008). However, McKay et al., (2014) reported that age-group was not a distinguishing factor in coaches' awareness and perceptions of injury prevention strategies. The results of this present study do not confirm or refute these findings, as 47% of coaches of U7-U12 teams vs. 43% of coaches of U13-17+ teams who agreed/strongly agreed regarding the benefit of NSTs. Due to the increased injury risk in adolescent footballers leading to conditions such as early onset osteoarthritis and subsequent withdrawal from physical activity, the lack of clear differentiation regarding the benefits of NSTs

between age groups could suggest that coaches perceive the main benefit of NSTs as the ability to prevent present injury rather than chronic long-term injury and disability (Morgan et al., 2018). Such views require further investigation.

3.4.3 Barriers and facilitators to implementing NSTs (Reach / Implementation / Maintenance)

In a review of IPEPs in ball sports, major barriers in implementation included time constraints, poor effectiveness and lack of specificity to the sport (O'Brien & Finch, 2014). Supporting findings in similar research (De Ste Croix et al., 2020), coaches in this study ranked "lack of knowledge" as, by far, the largest barrier to NST implementation. "Time" was also noted as a major barrier to the implementation and adherence to the FIFA 11+ (Junge et al., 2011) . Moreover, during interview, although coaches identified time most commonly when discussing barriers to implementation, coaches also noted lack of knowledge directly or indirectly as a barrier to NST implementation. Additionally, researchers have consistently reported that gaps in grassroots coaches' knowledge would harm implementation of IPEPs (Joy et al., 2013; McKay et al., 2016; O'Brien & Finch, 2016). Interestingly, even when coaches have the required knowledge, they may refrain from challenging the beliefs of players, opting instead to remove or add elements of an IPEP, thus going against the scientific foundation of the programme (McKay et al., 2016). This is a consideration for implementation barriers as, during interview, coaches mentioned the need for buy-in from players and parents, suggesting their influence on successful NST implementation is significant. As such, implementation of NSTs or IPEPs may suffer due to the coaches' inability/reluctance to transfer knowledge to players/stakeholders rather than due to the lack of knowledge of coaches themselves.

Lack of education around IPEPs would reduce successful implementation (De Ste Croix et al., 2020). Results of this study show that coaches supported the need for education on NSTs, ranking this the most important facilitator by the survey respondents. Donaldson et al., (2018) suggested that NGB's buy-in was key in educational development for coaches using FIFA's 11+, where buy-in can lead to successful implementation of IPEPs (Junge et al., 2011). De Ste Croix et al., (2020) goes further, suggesting education regarding IPEPs should form a mandatory part of CPD. To fill these knowledge gaps, 71% of coaches believed educational training should take place via face-to-face workshops. Moreover, review of open questions in the survey revealed preference towards face-to-face CPD over online sessions. This view is supported, in the main, by the coaches of female footballers during interview, although some interviewed coaches reported the beneficial impact of online or hybrid CPD sessions. While there is limited research exploring the effectiveness of face-to-face vs. online/remote coach education, Santos et al., (2019) found that online coach education had some success, mainly due to logistical considerations, but suggested online courses could be supplemented by practical face-to-face components. Santos and colleague's (2019) ability to generalise their findings to the wider coaching population is limited due to the low sample size in their study (n = 7), and further research in this area is of paramount importance due to changes in living post the COVID-19 pandemic.

Lack of time was noted as one of the major barriers to NST implementation in this study (being ranked as the biggest barrier by the second highest number of coaches) as well as being commonly noted throughout interview discussions. There were mixed opinions from coaches regarding the duration that they believed a NST should last, with less experienced coaches believing NSTs should be shorter in duration. Most coaches surveyed (63%) suggested that they would be confident completing a NST with their players. It was found that 37% of coaches felt either unconfident or unsure about their ability to conduct an NST with their players. This is not surprising given the perceived gap in knowledge and the influence this might have on coaches'

confidence levels (De Ste Croix et al., 2020). Taken together, these results strengthen the view that education for NSTs (and IPEPs) need to be prioritised.

3.5 Practical application - The co-production of the NST

The views of coaches have been collected in four phases in this thesis (see Figure 5). These views can be combined with the literature outlined in Chapter 2 to co-produce a NST for use by grassroots coaches of adolescent female footballers.

3.5.1 NST screen selection

Chapter 2 reviewed a variety of NSTs that could be used by grassroots coaches of female adolescent footballers. However, certain screens require significant equipment, which is a limitation to NST implementation noted in Chapter 3. As a result NSTs that required expensive equipment, which would likely be unaffordable for grassroots clubs, can thus be omitted from further discussion. NSTs omitted due to this included the SLCMJ, which require force plates. Additionally, other screens, such as for the assessment of trunk dominance can also be omitted from the NST. This is because there is limited research into the assessment of trunk dominance, except for assessments requiring specialised equipment that isolates the motion of the lumbar spine (Zazulak et al., 2007).

A limitation of the selected screens used to form the NSTs is the potential for selection bias. Hegedus et al. (2014; 2015) highlights the lack of consistency in naming many NSTs. For instance, the single-leg hamstring bridge test developed by Freckleton et al. (2014) is inconsistently abbreviated in the literature as both "SLHB" and "SLBT" (Mahnic et al., 2021; Freckleton et al.,

2014). Furthermore, there is no universally accepted collective term for NSTs, which complicates the process of identifying relevant studies. Consequently, the author's knowledge of naming conventions, which was utilised in the literature review in Chapter 2, may inadvertently narrow the range of screens considered for inclusion in the final NST, thereby restricting its diversity and comprehensiveness.

There has been no NST reviewed that has simultaneously been shown to have 1) moderate or above levels of intrarater and interrater reliability when used by novice assessors (as grassroots coaches are assumed to be), 2) been concurrently validated against gold standard measures (such as isokinetic dynamometry), 3) shows strong ecological validity for the use within football and 4) has been studied using an adolescent female football population. The fact that some NSTs are validated against their ability to predict and measure injury risk whereas others are only measured against their ability to monitor performance adds further complexity to the discussion about NST selection for use by grassroots coaches of female adolescent footballers.

Nevertheless, McCunn et al., (2017) developed the Soccer Injury Movement Screen (SIMS), which was shown to have good to excellent intrarater and interrater reliability. There are five screens that make up the SIMS; anterior reach, single-leg deadlift, in-line lunge, single-leg hop for distance and tuck jump. As a result of literature reviewed in Chapter 2 and the information gathered from coaches in Chapter 3, a modified version of the SIMS is being proposed for the NST screens.

Firstly, the anterior reach will be assessed using the mSEBT protocol, as this adds further information to the anterior reach, whilst not requiring significant additional time. Both the single-leg deadlift (SLDL), in-line lunge (ILL) will be omitted. McCunn et al., (2017) reported that the SLDL showed differences in flexibility between male and female participants, with females demonstrating increased rates of hamstring flexibility. However, in a later study, McCunn et al.,

(2018) reported that athletes with greater flexibility assessed by the SLDL had an increased risk of hamstring injury. As there is significant conflicting data regarding the association between flexibility and injury (Myer et al., 2008; Thacker et al., 2004; Cejudo et al., 2019), the use of the SLDL would be questioned. The ILL forms the basis of many foundational movements in sport and is widely used as part of football warm-up routines, making the action familiar to players (McCunn et al., 2017; Duncan et al., 2018). However, novice raters showed only moderate interrater agreement when assessing the ILL compared to excellent and/or substantial agreement on all other elements of the FMS, with ICC test–retest reliability being rated as poor elsewhere (Read et al., 2016). Furthermore, the ILL was replaced with a step-up exercise for the RTSB by a panel of paediatric exercise experts due to its complexity (Duncan et al., 2018). Finally, the ILL did not correlate with measures of power, speed, and balance in a cohort of post adolescent male and females (mean age = 25.1 ± 3.7 years). For these reasons, the ILL will be removed from the modified SIMS due to the proposed benefits of other NSTs discussed below.

As a result, the following individual NSTs are recommended to make up the full NST for used by grassroots coaches of adolescent female footballers.

3.5.1.1 Assessment of dynamic stability – The mSEBT (anterior reach component only).

The mSEBT can assess dynamic strength and balance, requiring the participants to utilise visual, vestibular and somatosensory systems to complete the assessment (Ko, et al., 2020; Philp et al., 2020). While the YBT exhibits higher interrater reliability scores than the mSEBT, its reliance on equipment may limit its application in grassroots football (Chimera & Warren, 2016). Nevertheless, the mSEBT has demonstrated reliability in assessing dynamic stability (Bulow et al., 2019). With movement required in only three directions, the mSEBT offers a quicker and more user-friendly option for novice raters, such as grassroots coaches, compared to the SEBT, especially important as time limitations have been consistently cited as a barrier to NST implementation (Chapter 3).

Notably, the mSEBT shows consistency across participant ages (Philp et al., 2020), suggesting its suitability for use during maturation. Therefore, it is recommended for grassroots coaches working with female adolescent footballers. However, on-field coaches may overlook the importance of the measurement grid, a crucial aspect of the mSEBT. Considering real-world implementation challenges, an alternative approach could involve solely utilising the anterior reach component of the mSEBT. While injury risk identification isn't the primary screening goal, studies have shown that the anterior reach component can identify adolescent female performers at an increased risk of knee and ankle injuries (Plisky et al., 2006; Bulow et al., 2019). This not only aids in injury risk assessment but also allows grassroots coaches to provide personalised neuromuscular training recommendations for participants. Finally, literature advocates incorporating the anterior reach component of the mSEBT into a screening battery designed for adolescent female footballers (McCunn et al., 2017).

3.5.1.2 Assessment of leg dominance – Single Leg Hop for Distance

Compared to other screens, such as the TJA, the primary aim of the SLHD is to assess between-limb asymmetry. By assessing both horizontal and vertical movement, the SLHD demonstrates sound ecological validity for use in football (McCunn et al., 2017). Moreover, the single-legged nature of the jump more closely replicates football activity, where jumps, sprints and landings are often performed on one limb (DiCesare et al., 2019, Beese et al., 2015). The SLHD has also been shown to be reliable when being assessed in real-time, important for coaches who are time and equipment limited, as discussed previously (McCunn et al., 2017). Whilst the SLHD has not been shown to correlate with sporting performance (Bishop et al., 2021), emerging research suggests that the SLHD may potentially be able to identify performers at increased risk of injury (Read et al., 2018; McCunn et al., 2018). Where both the single and triple hop variants of the SLHD have been discussed collectively (see Chapter 2), greater between-limb asymmetry was demonstrated by the single-hop SLHD over the triple-hop SLHD (Bishop et al., 2021). This suggests that the single-

hop SLHD would be more beneficial to be used, and aids implementation into the NST due to its speed to conduct. Thus, not requiring equipment (such as the SLCMJ which required expensive laboratory equipment), and being quick and easy to administer, the single-hop SLHD can be recommended for use by grassroots coaches of female adolescent footballers.

3.5.1.3 Assessment of leg dominance and ligament dominance – Modified Tuck Jump Assessment.

Although categorised as a NST for the assessment of ligament dominance, the TJA has also been shown to assess leg dominance more consistently than leg dominant-specific NSTs such as the SLHD (Hoog et al., 2016). The reliability of the TJA has been questioned due to the complexity of its scoring criteria (Read et al., 2016). However, specific criteria of the TJA have been shown to have improved reliability compared to assessment of composite scores (Lindblom et al., 2021). Initial research shows the mTJA to be reliable for both composite and individual scores (Fort-Vanmeerhaeghe et al., 2017).

The mTJA has been shown to correlate with injury risk (Fältström et al., 2021, Bates et al., 2015), but this view is not universally reported in research. However, specific aspects of the TJA, 'lower extremity valgus at landing' and 'thighs not reaching parallel to the ground' were able to identify reduced neuromuscular control in adolescent females (Klugman et al., 2011). Moreover, the 'knee and thigh motion' elements of the TJA has been shown to identify excessive knee valgus in female footballers, being recommended as a screening tool itself by Mayhew et al., (2017). These 'knee and thigh motion' elements constitute three specific elements of the TJA (and mTJA);

- Lower extremity valgus at landing
- Thighs not reaching parallel to the ground
- Thighs not equal side to side

Elements of the TJA and mTJA have been shown to be reliable. The ecological validity of the TJA is assured due to the relevance of plyometric screening to football, as well as a NST which induces fatigue (Fort-Vanmeerhaeghe et al., 2017). Camera equipment (smartphones) could be used for screen recording (Rogers et al., 2019), and this equipment is readily available for grassroots coaches (FG2). Therefore, a modified version of the TJA, using the above three TJA elements, can be recommended for use by grassroots coaches of female adolescent footballers.

3.5.2 Developing the CPD session

Chapter 2 discussed the epistemological and operational considerations regarding the development of a coach education session centred around a lower-limb NST. Using a co-produced, evidence-informed approach, the following recommendations and considerations are made to structure the NST CPD session itself.

1. A 'coach training' session – Chapter 2 predominantly used the phrase 'coach education'. This was due to most literature using the same term. However, a distinction is made between 'coach education' and 'coach training'. The developed session will be a 'coach training' session in that the session will not be bound by a formal curriculum requiring summative assessments and accreditation and will be of shorter duration focusing on a specific development of a coaching skill (movement screening). This is of specific importance due to the consistently referenced time barrier for CPD for volunteer coaches. Time is a recurring theme throughout the focus group discussions and is highlighted as a key consideration for post-session activities. Coaches expressed that they should not be required to undertake time-intensive tasks (such as analysing video data to score screens). Additionally, they emphasised that any resultant recommendations or exercises provided to players should occur outside of regular coaching sessions to avoid impacting their

allocated delivery time. This concern underscores the need for efficient, streamlined processes that integrate seamlessly into coaches' existing routines.

2. A non-formal session - the session(s) will be a non-formal session(s). A limitation with formal coach education is that often coaches are mandated to study content that they do not believe is relevant to them. A learner-centred approach of content selection is recommended in literature. A benefit of non-formal coach education is that it allows the student coach to select content that they believe would be beneficial for their own learning journey outside of the mandated NGB curriculum. Moreover, a non-formal session with limited prerequisite requirements will be more time-efficient for learners.

   A major limitation of non-formal education cited in literature revolves around the notion that student coaches would be 'talked at' with limited ability to apply experiential learning. Yet, as noted in this chapter, coaches believed that those developing and delivering the CPD session need sufficient knowledge and standing within the game. Coach educators should be well-prepared and knowledgeable, with strong presentation, communication, and demonstration skills, supported by practical experience and accessible language (Nelson et al., 2013). Coach interviews emphasised this with participants stating they watch the coach educator's demonstrations to make sure they themselves were performing actions correctly (Participant 5).

4. A social constructivist learning paradigm / Knowledge into practise – the session(s) should be created through a social constructivist lens. It is recognised that the development of coach education sessions on NSTs will have elements of didactic tuition. This is required to inform coaches of evidence-based protocols for which the individual screens are based.

This will reduce the ability of the student coach to learn via problem-based learning. However, where possible, a social constructivist learning paradigm should be applied to non-formal learning. Examples include encouraging coaches to discuss the barriers and facilitators to any NST outlined, as well as to debate the most effective implementation strategies for the NST at their own club or how to communicate resultant recommendations with players and parents/guardians. This will help seat the course in the real-world for participants, allowing the student coach to leverage their personal experiences, expertise, values, and abilities, resulting in the development of fresh insights within a learner-centred methodology. Despite the increased availability of sports science knowledge via sources like the internet, coaches still predominantly rely on fellow coaches and coaching conferences for information (Reade et al., 2008). The survey of over 100 grassroots coaches (outlined in this chapter) revealed limited awareness of NSTs, with lack of knowledge being the biggest barrier to implementation. This was primarily attributed to situational factors, such as limited time to access journals or restricted access to sports scientists (Martindale & Nash, 2013). These aspects solidify the notion that coaches need the ability to discuss challenges, barriers and opportunities with peers in order to resolve ideological conflict and ambiguity within their coaching practise. It is these discussions and interactions with coaches that would help the student coach (1) develop their understanding of the situation, (2) consider the relevance of the concept, (3) develop ideas appropriate for their coaching situation, and (4) integrate the concept with their other coaching practise in the planning and implementation of actions (Eraut, 2000).

5. A blended-learning approach – The overall CPD session should be made up of two components; an initial online session where the details of the specific screens are covered, followed by a practical face-to-face session. This would benefit coaches as it would allow them to complete the more didactic session required (see point 2) at a time and place to

suit the needs of the volunteer coach. Additionally, this would enable the coach to review the learning material both before and after the in-person session. This way, the coach's personal learning speed can be taken into consideration. It will allow the face-to-face session to be of a shorter duration (thus more time efficient for the coach), but more importantly, will allow the face-to-face session to be both predominantly practice and activity based, allowing for increased coach-to-coach interaction to take place (see point 2). This is important as coaches have talked about their desire for face-to-face learning. However, although coaches genuinely discuss fully online vs fully off-line CPD approaches, the online learning methods did receive some support among coaches as live (synchronous) online workshops were ranked the second most desired CPD modality, ahead of online asynchronous tools, which was ranked third. This is not surprising given that coaches are now increasingly more open to using online support for learning, a trend accelerated by the COVID-19 pandemic (Leeder et al., 2021; Stoszkowski & Collins, 2022). The online portal could also include a feature that facilitates communication among coaches, fostering the growth of the NST coaching community.

6. A practical, student-centred approach – This chapter also delves deeper into the specifics of in-session and post-session activities. The main recommendation from focus group participants was the ability to practise the screens themselves within the session. During this practise element, coaches suggest that, consistent with the constructivist recommendations, discussing the practical element of the screens with their coaching peers, specifically related to their potential use an implementation within the industry, would be important in any CPD session.

The coach education CPD session developed as part of this thesis should not be regarded as the final 'product'. To improve the real-world application and implementation of the NST coach education session, the session should be developed via a bottom-up approach (rather than the usual top-down approach). This chapter has gathered information from grassroots coaches, helping in the development of the pilot CPD session (Chapter 4). The evaluation of the 'first draft' of the coach education session follows (Chapter 4), allowing for alterations and recommendations to be made to improve the overall acceptance of the course by the end-user (Chapter 5).

3.6 Limitations

There are several limitations that should be acknowledged across the combined data collection phases involving the survey, follow-up interviews, and focus group. One primary limitation lies in the survey response rate and overall sample size, which, when compared to the broader population of grassroots football coaches in England, limits the generalisability of the findings. A lower response rate could be expected given that survey invitations were sent to generic club inboxes rather than directly to individual coaches, a challenge echoed in similar studies reporting response rates around 14% (Duncan et al., 2022). Volunteer coaches, often operating under significant time constraints, may have chosen not to participate. Previous research has also noted that coaches operating outside of academy or national team environments tend to exhibit lower response rates (Joy et al., 2013). Nevertheless, the sample size achieved in this study aligns with or exceeds those reported in comparable research (Mawson et al., 2018).

Further limitations apply to the interview phase, particularly regarding the number of participants. While the sample size was modest, interview data reached saturation based on Buckley's (2022)

definition. The number of interviews also aligns with Dworkin's (2012) recommendations for qualitative inquiry and reflects practices in other studies exploring grassroots coaches' perceptions of barriers in coach education (Søvik et al., 2017). One potential concern is the presence of "interest bias" - with 72% of survey respondents expressing a belief that NSTs would be beneficial, it could be argued that only coaches already positively disposed to NSTs chose to participate. However, given that the majority of coaches reported having no prior knowledge of NSTs, this bias appears unlikely. That said, requiring completion of the survey prior to the interview may have led some participants to conduct additional research beforehand, possibly shaping their responses. Conversely, the admitted lack of prior knowledge may also have limited the depth of insight participants could offer regarding NST use in grassroots youth football.

While the focus group phase added valuable practitioner insight to the co-development of the NST and its associated CPD, it is important to acknowledge limitations in both the composition and scale of this group. Only two coaches participated in the focus group, both holding UEFA C qualifications and actively coaching female adolescent footballers. Although their views aligned with broader trends observed in the survey and interview phases, the very small sample size constrains the generalisability of these findings. These participants, due to their prior engagement in interviews and interest in the topic, may also reflect a more motivated or engaged subset of grassroots coaches, introducing potential selection bias. While their feedback was instrumental in shaping practical recommendations for the NST and CPD delivery (e.g., emphasis on hybrid learning, time efficiency, and minimal equipment), caution should be exercised in extending these insights to the wider coaching population. Future research should aim to replicate the co-collaborative element with a larger, more diverse sample to enhance the broader applicability and robustness of the final NST framework.

While larger focus groups are often recommended, they can risk marginalising quieter voices, potentially reducing equity and inclusivity (Sim & Waterfield, 2019). Furthermore, low sample sizes are not uncommon in the coaching literature (Søvik et al., 2017), and case study approaches involving similarly limited numbers have been successfully used in coach education research (e.g., Stodter & Cushion, 2014). The structure of the focus group - an online, semi-structured session - was also a compromise. A more intensive co-production session might have offered richer insights, but such an approach was not feasible due to the time and access constraints frequently reported by volunteer coaches (as outlined in this chapter). In response, a pragmatic and inclusive online session was arranged to ensure that participants' voices could still be heard.

Moreover, although the focus group drew upon elements of 'co-production', it is acknowledged that it may not fully meet the rigorous definitions set out in the literature, where co-production typically involves participants from the earliest stages of research design, including the formulation of research questions (Smith et al., 2023). Nonetheless, this phase sought to incorporate end-user perspectives meaningfully, particularly in the development of the final screening tool and CPD session. When considered in conjunction with the survey and interview findings, it could be argued that the voices of grassroots coaches have been consistently represented throughout the 'co-collaboration' development process. Viewed collectively, these phases (see Figure 5) contribute to a more robust understanding of coach engagement, despite individual limitations in participant numbers across each method.

Finally, the survey conducted in this chapter did not specifically ask respondents whether they coached male or female players. Given that the overarching aim of the thesis was to develop a CPD tool tailored for coaches of female grassroots footballers, filtering participants by the sex of the players coached could have provided more targeted insights. However, this was not deemed critical at the survey stage because the broader coaching population shares many common barriers,

facilitators, and perceptions around using NSTs, regardless of player sex. The survey aimed to gather a wide perspective on general grassroots coaching knowledge, confidence, and attitudes towards NSTs, rather than to perform comparative subgroup analysis. Furthermore, later phases of the research in this chapter (interviews and co-production focus group) were deliberately focused on coaches of female players, ensuring that the final CPD tool was shaped by the appropriate target audience. As such, the absence of a filtering question in the initial survey does not undermine the relevance or applicability of the study's outcomes.

3.7 Conclusions

This chapter has explored the perspectives of grassroots football coaches regarding the proposed development of a NST and accompanying CPD session tailored for coaches of adolescent female footballers. Employing a mixed-methods approach consisting of an online survey and follow-up interviews, the research sought to investigate current coaching practices, perceived barriers to injury prevention, and attitudes towards the integration of field-based screening tools into routine coaching sessions. The findings offer critical insight into the practical and contextual realities faced by volunteer coaches, many of whom operate without access to formal sports science support or medical infrastructure. Indeed, this study is the first to ascertain the views of grassroots coaches regarding NSTs, a cohort that is often overlooked when it comes to sport science research (McKay et al., 2016).

A key outcome of this study is the clear indication that, while awareness of neuromuscular screening is limited among grassroots coaches, there is substantial openness to adopting such tools - provided they are practical, time-efficient, and supported by relevant coach education. The findings highlighted a strong desire for CPD content that is directly relevant to the needs of

coaches working with female adolescent players - particularly in relation to injury risk identification.

Despite the strengths of the study, including a triangulated approach to data collection and the involvement of a specific end-user group, the limitations should be acknowledged. The survey response rate and sample sizes for the interviews, survey and focus group were relatively modest, limiting the generalisability of findings. However, the samples align with precedent in the coaching literature and yielded rich qualitative data that reached thematic saturation for the interview participants. The potential for selection bias - particularly interest bias among survey respondents - was considered, although mitigated by the participants' self-reported unfamiliarity with NSTs.

Crucially, this chapter forms part of a broader programme of pilot research aimed at developing a field-based screening tool that is accessible to and usable by grassroots coaches. The findings presented here reinforce the importance of embedding end-user voices into the development process from the outset. By identifying the contextual barriers, knowledge gaps, and practical requirements faced by coaches, this chapter contributes foundational knowledge to the design of a tool that aligns with real-world coaching environments. The insights gained from this chapter will directly inform the subsequent phases of tool development and implementation, while also reinforcing the need for targeted CPD resources that are firmly grounded in both academic research and the realities of coaching practice. The data presented enabled a cross-referencing of coaches' perspectives with the academic literature, facilitating the identification and refinement of the specific screens that should be included within the screening tool. Furthermore, the input provided by end-user coaches informed the development of clear recommendations regarding the format, content, and delivery modalities of the accompanying CPD session. Such training may not have been previously perceived to meet the needs of the end user, limiting the success of the training and long-term implementation and maintenance of any NST (Duncan et al., 2022). These

recommendations now form the basis for a pilot project to test both the screening tool and its associated educational component in real-world grassroots coaching environments.

Chapter 4: CPD session development and pilot testing

4.1 Introduction

The preceding chapters of this thesis were dedicated to compiling the essential information necessary for creating a NST and the CPD session that is tailored for grassroots coaches working with female adolescent football players. In Chapter 2, the focus was on identifying the potential evidence-led need for NST development, the NST screens and discussing relevant coach education literature. Chapter 3 was dedicated to collecting insights from existing coaches, including their understanding of neuromuscular movement screening, and perceptions regarding confidence, obstacles, and facilitators related to NST implementation. Crucially, the novel insights gained from surveys, follow-up interviews, and co-production focus groups provide a new and comprehensive perspective of coaches' views on how an NST and its associated CPD session could be designed and developed to address real needs and significantly enhance volunteer coach practices. Finally, Chapter 3 reconciled these views with existing academic literature to identify appropriate screening choices and delineate the andragogical principles upon which the CPD session can be formulated.

Drawing on the comprehensive research data obtained from coaches throughout Chapters 3, a pilot investigation to evaluate the practicality and potential value of the NST was designed as a blended session, comprising 1) an online NST CPD session, and 2) a field-based NST CPD session.

4.2 Method

4.2.1 Participants

Participants were invited to complete the online NST (oNST) anonymously via a variety of dissemination methods. Female or mixed-sex grassroots football clubs in England were sent emails inviting coaches to complete the oNST. Club email addresses were obtained as outlined in Chapter 3 and filtered to show only those who contained female or mixed-sex teams. Facebook was utilised to increase the number of participants, using the same process outlined in Chapter 3, and participants were contacted via LinkedIn and Twitter ('X') after manually searching for England-based "grassroots football / football coach". The need for participants to currently coach female footballers was outlined in these social media posts. The initial emails / social media posts were followed up after four weeks to increase the response rate. Any participants that voluntarily disclosed contact details during the completion of the survey in Chapter 3 were also contacted directly (outlining the inclusions criteria as currently coaching female footballers) as were any coach participant who had been involved in interviews as part of this thesis. Participants did not receive a reward or benefit for completing the survey. The oNST was live from 11th March 2024 to 31st May 2024. Ethical approval was granted from the University of Gloucestershire Research Ethics Committee for both the oNST and inNST (Appendix 5 and 6).

During the oNST, participants who voluntarily requested and in-person session were contacted directly via the email address they provided, inviting them to take part in the in-person NST (inNST). This email also sought feedback from the participants as to the potential locations for the inNST session, as well as offering the participant the opportunity to invite coaching colleagues to partake in the inNST, even if said colleagues had not completed the oNST. The inNST sessions were scheduled to take place between 1st May – 30th June 2024.

4.2.2 Initial pilot testing

To improve the face and content validity of the CPD session (oNST, post-oNST survey, inNST and post-inNST survey), a pilot test was conducted with a small sample (n = 5) of football coaches, encompassing both more experienced regional coaches and local grassroots coaches. The feedback from this pilot testing group was compiled and analysed, leading to minor adjustments in the CPD session before research commenced. Of note, the pilot testing cohort included the coaches who participated in the co-production interviews (Chapter 3), thus further enhancing the co-production ethos of this research.

4.2.3 NST Screen selection

The below screens were used for both the oNST and inNST. The rationale for their use in the overall NST tool is outlined in Chapter 3.5.

- The anterior reach (AR) portion of the mSEBT for assessment of dynamic stability
- Single Leg Hop for Distance (SLHD) for assessment of leg dominance
- Modified Tuck Jump Assessment (mTJA) for assessment of leg dominance and ligament dominance

The method of conducting and scoring each screen has been previously outlined in literature (Fältström et al., 2021; Ko et al., 2020; Kotsifaki et al., 2022; McCunn et al., 2017) and was used as the basis for instruction in this tool. For a detailed description of the protocols used for each individual screen (including set up, conducting the screen and scoring) see Appendix 7.

4.2.4 Exercise prescription selection

A full review of the corrective exercises prescribed following the NSTs included in the oNST is beyond the scope of this thesis. However, it is important to highlight FIFA's 11+, an established IPEP that is widely supported in the literature. Pardos-Mainer et al. (2019) found that participation in the 11+ improved unilateral jumping, dynamic balance, and reduced lower-limb asymmetries in adolescent female footballers. Similarly, Dix et al. (2021) reported meaningful reductions in knee valgus collapse, suggesting that regular use of the 11+ may lower ACL injury risk during cutting manoeuvres. While Dix et al.'s study focused on adult athletes, Thompson et al. (2017) found similar benefits in pre-adolescent female players, including reduced peak knee valgus moments during double-leg jumps. A systematic review by Asgari et al. (2023) also confirmed that mid- to long-term implementation of the 11+ improves several biomechanical and physical attributes relevant to injury prevention.

Despite these benefits, the programme presents challenges, with time being the most cited. Coaches often modify or shorten the 11+, potentially reducing its overall effectiveness (Junge et al., 2011). As highlighted in Chapter 3, this reinforces the need for exercise prescriptions that are more time-efficient, targeted, and specific.

The original 11+ was developed for players aged 14 and older (Rössler et al., 2016b). However, most coaches in this study (45%) worked with U13 teams, and a further 43% coached players just above this level. Encouragingly, the child-adapted FIFA 11+ Kids programme has shown measurable improvements when used with younger players (Rössler et al., 2016b). Given the strong evidence supporting the 11+ Kids for players under 13 and the original 11+ for older

players, elements from both IPEPs can be validly embedded into recommendations arising from this research.

Time remains a key constraint both in this study and across the literature. As noted, coaches often lack time to implement the full FIFA 11+, leading many to use only selected exercises. To support successful implementation of NST-informed interventions in grassroots settings, exercise prescriptions must be both practical and efficient. Exercises will therefore be selectively adapted from the two FIFA programmes and aligned with the two primary age categories (see Table 9).

Table 9. Post NST exercise prescriptions

Screen	**Mechanism screened**	**Exercise prescription if positive**
mSEBT (AR component only).	Dynamic stability	Single leg stance progression ‡ Single leg stance progression †
SLHD	Leg dominance	Single legs jump progression ‡ Vertical jump progression (exercise 12) †
mTJA	Leg dominance	Single legs jump progression ‡ Vertical jump progression (exercise 12) †
	Ligament dominance	Spiderman progression ‡ Sideways Bench Static progression †
‡ Outlined in FIFA 11+ Kids. Exercise prescription recommended for ≤ 13 year olds † Outlined in the FIFA 11+. Exercise prescription recommended for >13 year olds		

Recent evidence further supports this approach. Prvulović et al. (2024) found that six weeks of plyometric training significantly reduced lower-limb asymmetries in young female athletes. A meta-analysis by Sun et al. (2025) confirmed the efficacy of unilateral training in reducing asymmetries

and related injury risks. Together, these findings support the inclusion of unilateral plyometric exercises to address leg dominance. Accordingly, the Single-Leg Jump Progression (Exercise 5 from the 11+ Kids) is recommended for U13 players, and the Vertical Jump Progression (Exercise 12 from the 11+) for those aged 13 and above.

As discussed in Chapter 2, ligament dominance (excessive dynamic knee valgus) is a known risk factor. Wilczyński et al. (2020) reviewed several exercises shown to reduce valgus moments, with an emphasis on strengthening gluteal muscles. Glute and side-bridge exercises improve hip stability and reduce knee valgus loading. For participants under 13, the Spiderman exercise (Exercise 6 from the 11+ Kids) is recommended. For those 14 and over, the Sideways Bench Static (Exercise 8 from the 11+) is advised.

Although limited, some research focuses specifically on female populations. Rasool and George (2007) demonstrated that single-leg dynamic balance training can significantly improve stability in a short period. Single-leg balance exercises feature in both FIFA programmes. Therefore, the Single-Leg Stance (Exercise 3 from the 11+ Kids) and the Single-Leg Stance Progression (Exercise 10 from the 11+) are confidently recommended for balance-focused interventions across age groups.

While the flow-chart (Figure 11) provides a targeted pathway for addressing individual screening outcomes, it is worth noting that both the 11+ and 11+ Kids have demonstrated broad benefits at the team level, regardless of individual deficits. Thus, coaches could reasonably consider implementing these programmes universally across squads, with the screening process serving

more as a means of reinforcing and individualising established best practice rather than as a prerequisite for participation.

A flow chart of exercise prescription recommendations, based on the specific screens, is show below (Figure 11).

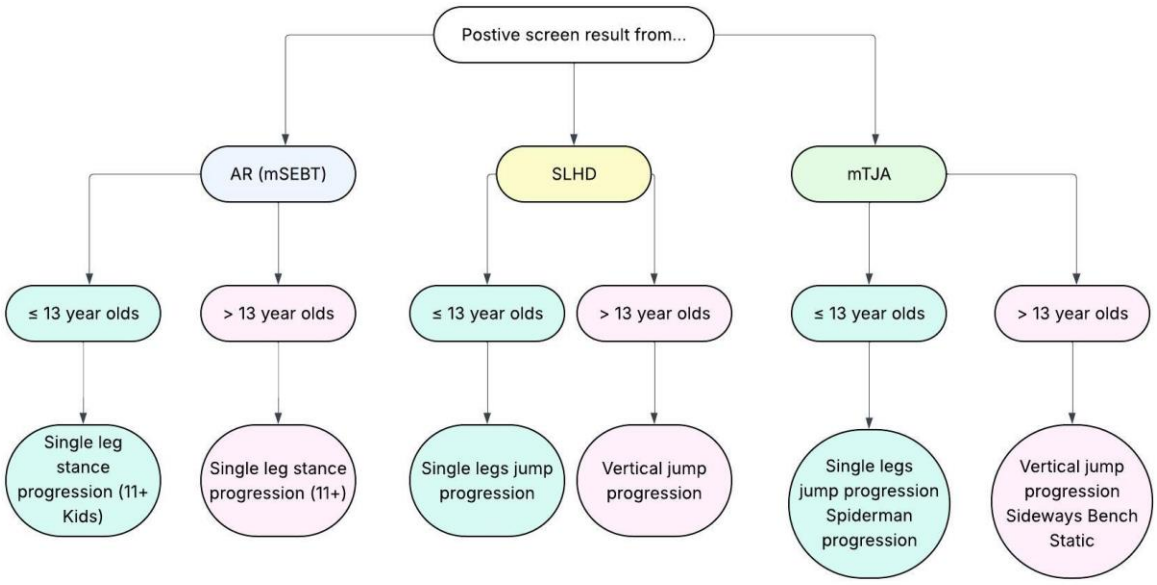


Figure 11. Exercise prescription recommendations flow chart

4.2.5 Online NST tool development

The oNST was created using Microsoft PowerPoint and integrated into Wooclap (Brussels, Belgium) to function as a web-based tool, allowing participants to use it without needing any specialised software other than a web browser. All materials, including videos produced using Microsoft Clipchamp and uploaded to YouTube for embedding into Wooclap, were specifically and independently developed for the oNST by the author for this novel project. A copy of the

oNST is linked here, with screenshots provided in Appendix 8. An overview of the participant's progress through the oNST is shown in Figure 12.

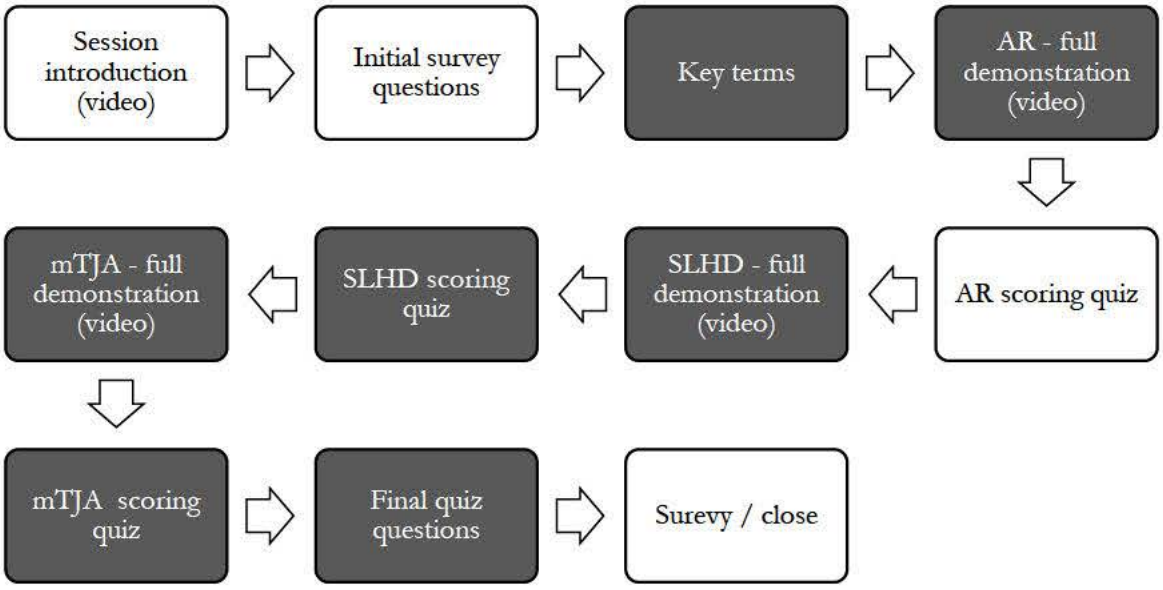


Figure 12. Progress through the oNST. The 'education section' of the oNST is highlight in grey with white text

Participants were sent instructions to help them join the oNST as well as the link and associated QR code. On the landing page, participants were able to download an additional screening help sheet (Appendix 9) as well as Research Participants Privacy Notice - University of Gloucestershire (Appendix 10) and Participant's Debrief sheet (Appendix 11). The oNST started with a disclaimer and implied consent slide (Appendix 12). Prior to the introductory video, Questions one to three asked participants to rate their knowledge (1-10 scale), confidence (1-10 scale), and perceptions of NSTs (Likert style 'very positive' to 'very negative'). These answers would be compared to similar questions post completion of the oNST to gauge changes in the participant's perceptions of their ability. Questions four through nine focused on the demographic and coaching background of the participants, utilising tick-box categories. Respondents were prompted to provide information

such as age, sex, highest football coaching qualification, coaching experience duration, and specifics about the sexes and age groups they coached (Table 10).

4.2.5.1 Education section of the oNST

After the participants had completed the demographic questions, they moved into the 'education section' of the oNST. The 'education section' started with an introduction section which briefly outlined the CPD session encompassing both online and in-person components (Figure 12). A key advantage to the oNST itself was that it explained key terms to coaches, such as 'neuromuscular' and 'ligament dominance', and provided instructions on utilising the accompanying materials, including estimated timings. All videos in the oNST permitted users to pause and rewind at their convenience, aligning with the recommendations articulated by coaches in Chapter 3. Questions were embedded throughout the Wooclap oNST (questions 10-25). Screen-related questions posed throughout the oNST required users to evaluate the screening exercises, with correct answers and explanatory narratives furnished upon completion. Users had the flexibility to progress through the training at their own pace, unhindered by incorrect answers.

Throughout the oNST and upon completing, respondents were asked to answer survey and knowledge-check questions (see section below). Although the inclusion of corrective exercises based on NST screenings falls beyond the focus of this thesis, recognising the importance of providing coaches with a tangible outcome from the screening process (as outlined via the focus group in Chapter 3), participants were directed to literature regarding FIFA's 11+ Kids (Rössler et al., 2016b) at the conclusion of the oNST session.

4.2.5.2 In-session and post-session oNST survey.

The anonymous survey included in the oNST followed a format akin to the one detailed in Chapter 3 and was hosted and included as part of the Wooclap oNST. Data was gathered via questioning throughout the oNST. This included questions about the participant's demographic (questions 4-9) and the participant's views of NSTs (questions 1-3, 26-35), as well as answers to the knowledge-based questions that form part of the 'education section' of the oNST (questions 10-25). The 'education section' of the oNST was designed to reinforce user knowledge as well as highlighting the need to evaluate the video example correctly. All participants were required to complete questions one to 30. Only respondents who did not want to undertake an in-person session were signposted to complete questions 31 to 35. Questions one to three, and 26-35 followed a modified RE-AIM structure to that as outlined by Donaldson et al., (2018). See Table 10 for further details.

To improve the response rate of information gathered via the oNST survey, questions were designated as 'required.' This designation mandated respondents to outline a response for any 'required' question before advancing through the online survey. However, due to software limitations, participants were still able to navigate past questions using navigation arrows.

Table 10. oNST survey questions, including RE-AIM categorisation

Survey question	Question topic	RE-AIM category	Research question
1	Knowledge – pre oNST	Effectiveness	1, 4
2	Confidence – pre oNST	Effectiveness	1, 4
3	Perceptions of benefits - pre oNST	Effectiveness	1, 4
4-9	Demographic questions – sex, age, highest coaching qualification, year' coaching, who coach (sex and age group),	Reach	NA
10-25	X16 knowledge-check questions about the various screens ('education section')	Effectiveness	1, 4
26	Knowledge – post oNST	Effectiveness	1, 4
27	Confidence – post oNST	Effectiveness	1, 4
28	Perceptions of benefits - post oNST	Effectiveness	1, 4
29	Benefits of using NST with players	Effectiveness / Adoption	2, 3
30	Undertake inNST session?	Reach / Adoption	NA
31	Barriers – to undertaking inNST (open)	Reach / Adoption / Implementation	2, 3
32	Barriers – to undertaking inNST (rank)	Reach / Adoption / Implementation	2, 3
33	Facilitators – for undertaking inNST (open)	Reach / Adoption / Implementation	2, 3
34	Facilitators – for undertaking inNST (rank)	Reach / Adoption / Implementation	2, 3
35	Open facilitators and catch all	Reach / Adoption / Implementation	2, 3

4.2.6 In-person NST CPD session development

A field-based, in-person CPD session (inNST) was developed on the principles outlined in Chapter 3. Due to the voluntary nature of the sessions, session-by-session participant numbers and locations varied. A copy of the standard inNST session plan is found in Appendix 13. As a brief session synopsis:

The instructor welcomed the participants to the session and collected the completed participant Information and Consent sheets (Appendix 14) and Physical Activity Readiness Questionnaires

(Appendix 15). Participants were divided equally into pairs or small groups (maximum of four participants per group). Participants were instructed to undertake a participant-led warm-up in their pairs or groups, similar to that which they conduct with their own players (without ball-work).

Following the warm-up, participants were directed to screening stations with the necessary equipment, instructional help sheets and copies of QR codes for the session activities. For their initial task, participants scanned a QR code leading to an interactive Wooclap presentation. This presentation featured ranking questions (1-10) related to their current knowledge and confidence in using NSTs. Next, three screen stations were arranged, each focusing on a specific screen: AR, SLHD, mTJA (refer to Chapter 3.5 for details). Participants were guided to work through their assigned screen station, with each coach playing dual roles as a participant for the screen and the lead coach overseeing and scoring the screen. When possible, multiple coaches scored and compared results. Participants spent approximately 20 minutes at each screening station. Midway through, coaches were prompted to scan a QR code to revisit the Wooclap presentation. The instructor posed questions for coaches to discuss regarding the implementation of the screen at their club, including challenges with player and parental involvement, with coaches invited to add discussion points to the Wooclap presentation using their smartphone (Appendix 16). As an extension task if time allowed, coaches filmed themselves performing the screens via their smartphones, reviewing in slow motion to compare their initial and non-live scores. The instructor circulated between stations, facilitating discussions and offering protocol advice.

After completing all three screening stations, participant coaches engaged in a cool-down led by themselves. The instructor encouraged further peer discussions on the implementation challenges and facilitators of NSTs. The session concluded with an instructor-led review of the activities and guidance on AMC exercises. Participants received a QR code for a post-session feedback survey (Appendix 17).

As previously mentioned, resultant exercise prescriptions are based upon both FIFA's 11+ Kids and 11+ (see section 5.2.4). A YouTube video of each individual exercise was provided to coaches using a QR code (see Appendix 13 for links).

4.2.6.1 Pre/post-session inNST questions and feedback survey.

A pre/post-session feedback survey collected participant's views on the use of the session(s) as well as NSTs usage within their industry. The online survey, hosted by Jisc Online Surveys (https://www.onlinesurveys.ac.uk) and completed anonymously, adhered to formats discussed previously (see Chapter 3 and 'Post oNST survey'). Comprising 40 possible questions in total, the survey commenced with an introductory section spanning two pages, offering participant details about the survey. There followed an informed consent page, asking participants to consent to undertaking the survey. Answering 'yes' would direct participants onto the first question proper and answering 'no' routed respondents to a final 'thank you' page (Appendix 17).

After the preliminary information, the survey was divided into four sections, with participants completing the sections that were relevant to them. All participants completed Section 1 which contained questions required prior to the completion of the inNST. After this section the participants were instructed to continue with the inNST itself.

Post completion of the inNST, participants resumed the survey, answering a filter question about their experience using the oNST. If participants had also completed the oNST, they answered questions in Section 2 comparing the oNST to the inNST. If respondents had not completed the oNST, they proceeded directly to Section 3. Section 3 enquired as to specific feedback about the inNST. All participants completed Section 3 and Section 4, which investigated the respondent's views on NSTs in general (i.e. its use in their club etc) (Figure 13 and Tables 11 to 14). After the

session was completed, the participants were given Participant's Debrief sheet (inNST) (Appendix 18).

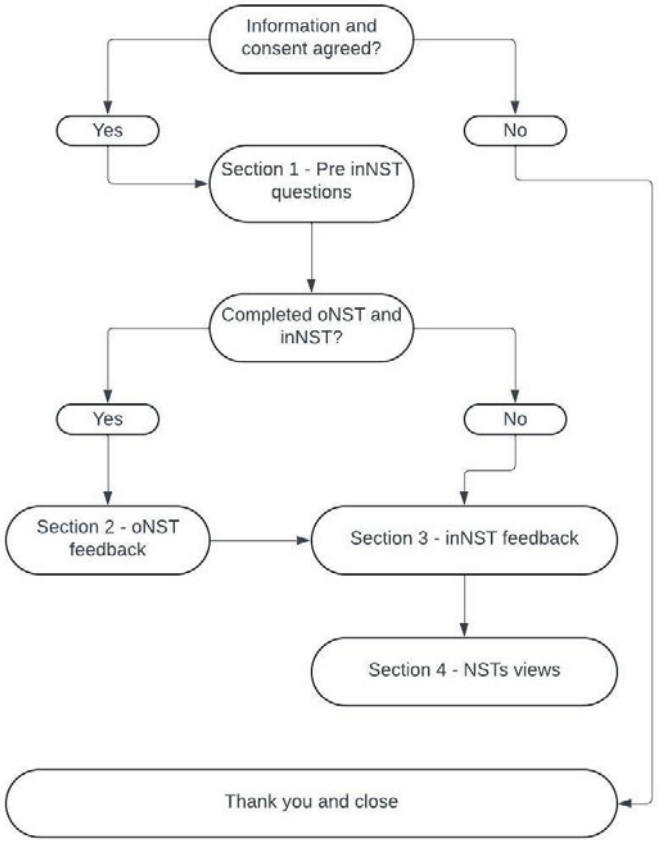


Figure 13. Progress through the pre/post inNST survey

Table 11. Pre/post- inNST session questions and feedback survey – section 1 (preliminaries)

Survey question	Question topic	RE-AIM category	Research question
1-6	Demographic questions – sex, age, highest coaching qualification, year' coaching, who coach (sex and age group),	NA	NA
7	Knowledge – pre inNST	Effectiveness	1, 4
8	Confidence – pre inNST	Effectiveness	1, 4
9	Perceptions of benefits - pre inNST	Effectiveness	1, 4

Table 12. Pre/post-inNST session questions and feedback survey – section 2 (oNST feedback). Only completed by participants who also undertook the oNST

Survey question	Question topic	RE-AIM category	Research question
10	Beneficial – learning content (screens)	Effectiveness	1, 4
11	Beneficial – preparing for inNST	Effectiveness	1, 4
12	Beneficial – knowledge vs inNST	Effectiveness	1, 4
13	Beneficial – knowledge to complete NST from oNST alone	Effectiveness	1, 4
14	Beneficial – confidence to complete NST from oNST alone	Effectiveness	1, 4
15	Beneficial – oNST should remain part of overall NST CPD	Effectiveness	4
16	oNST vs inNST - Knowledge	Effectiveness	1, 4
17	oNST vs inNST - Confidence	Effectiveness	1, 4
18	oNST vs inNST – attendance (including open follow-up question)	Effectiveness	1, 4
19	How to improve oNST	Adoption	1

Table 13. Pre/post- inNST session questions and feedback survey – section 3 (inNST feedback). Completed by all participants

Survey question	Question topic	RE-AIM category	Research question
20	Knowledge – post inNST	Effectiveness	1, 4
21	Confidence – post inNST	Effectiveness	1, 4
22	Perceptions of benefits - post inNST	Effectiveness	1, 4
23	Beneficial – learning content (screens)	Effectiveness	1, 4
24	oNST vs inNST - Knowledge (a NA response option available)	Effectiveness	1, 4
25	oNST vs inNST - Confidence (a NA response option available)	Effectiveness	1, 4
26	Beneficial – speaking to other coaches	Effectiveness	1, 4
27	Beneficial – speaking to other coaches re implementation	Reach	1, 4
28	Beneficial – knowledge to complete NST from inNST alone	Effectiveness	1, 4
29	Beneficial – confidence to complete NST from inNST alone	Effectiveness	1, 4
30	How to improve inNST	Adoption	4

Table 14. Pre/post-inNST session questions and feedback survey – section 4 (on NSTs). Completed by all participants

Survey question	Question topic	RE-AIM category	Research question
31	Future use of NST	Adoption	4
32	Perceptions of NST improved	Effectiveness	1, 4
33	Benefits of NST use	Effectiveness	1, 4
34	Barriers to overcome implementation issues	Implementation	2, 3
35	Facilitators required for implementation within club	Implementation	2, 3
36	Disseminating information to other cultures	Reach / Adoption	2, 3
37	Usefulness of CPD NST session for other coaches	Reach / Adoption	4
38	Desire to implement at club	Implementation	4
39	Continued use of NST at club (including open follow-up question)	Maintenance	4
40	Broad use of NST in industry	Adoption / Implementation / Maintenance	4

4.2.7 Research questions

The above CPD sessions and post-session surveys were designed in order to answer the following primary research questions.

1. Is an online and/or in-person CPD session effective in enhancing the knowledge, confidence levels and perceptions of grassroots football coaches of adolescent female footballers in utilising NSTs for player assessment?
2. What are the barriers and facilitators for the successful adoption and implementation of an online and/or in-person CPD session in grassroots adolescent female football?
3. How effective is a blended approach to CPD for grassroots football coaches of adolescent female footballers?

4.2.8 Survey analysis

The responses from all surveys were exported from the Wooclap and Jisc Online Surveys platforms and organised via Microsoft Excel 365. Descriptive statistics (percentage, mode and mean ±SD) were presented for any numeric, ranking and Likert question responses. Open question responses were analysed using a thematic analysis method as outlined in Chapter 3.

To determine any increase in knowledge and confidence pre- and post- intervention (oNST and/or inNST), a dependant samples t-test (or non-parametric equivalent) was performed using SPSS (version 29). Pre and post perceptions were determined by mode average and descriptive statistics. To determine if one CPD intervention modality was more successful in improving knowledge, perceptions and confidence pre- and post- intervention (oNST vs. inNST) an independent samples t-test (or non-parametric equivalent) was performed, if appropriate, using SPSS (version 29). Further, exploratory trends were investigated when noted. For example, the response rates per question in the Wooclap oNST were analysed using Spearman's rank-order correlation (SPSS version 29) to determine if the further the participants progressed through the Wooclap oNST platform the lower the question response rate (question "drop-off").

Given the limited current knowledge of coaches regarding NSTs (Chapter 3), it is hypothesised that both the oNST and inNST will improve the knowledge, perceptions and confidence of grassroots coaches of adolescent female footballers post intervention. Given the preference of coaches to undertake in-person CPD sessions compared to online sessions (see Chapter 3), it is further hypothesised that the inNST session will show an improvement in the knowledge, perceptions and confidence of grassroots coaches of adolescent female footballers post-inNST vs. post-oNST.

4.3 Results

4.3.1 Participants

4.3.1.1 oNST

A total of 36 participants started the oNST. The response rate for the survey was low, with an approximate response rate of 2% of all emails sent to clubs (approximately numbering 1811 emails).

Of these 36 initial participants 33% (n = 12) were excluded from analysis as the participant failed to answer any questions contained within the oNST. The age demographics of the remaining 24 participants is shown in Figure 14. The mode age of the participants was 35-44 years old with 42% of participants falling within this age bracket (n = 10). The majority (n = 15) of the participants were male (63%), with nine participants (38%) being female (Figure 15).

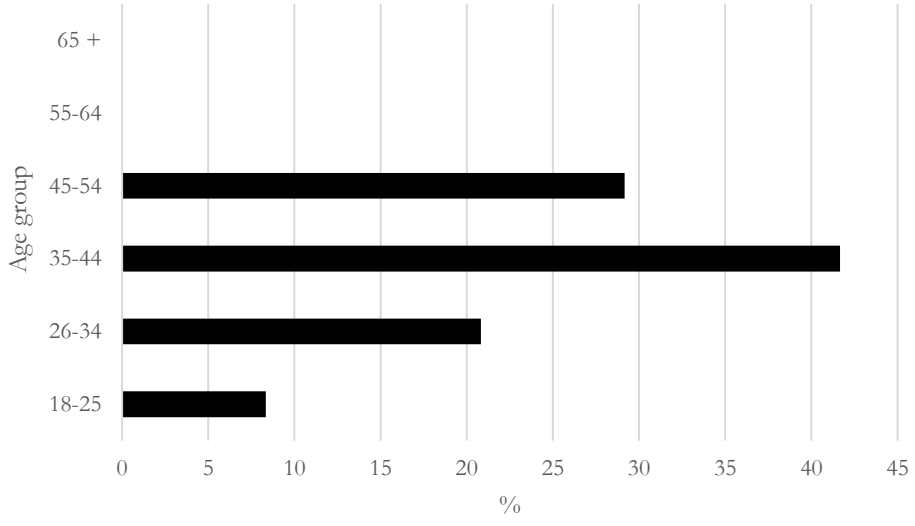


Figure 14. Age group of participants of the oNST

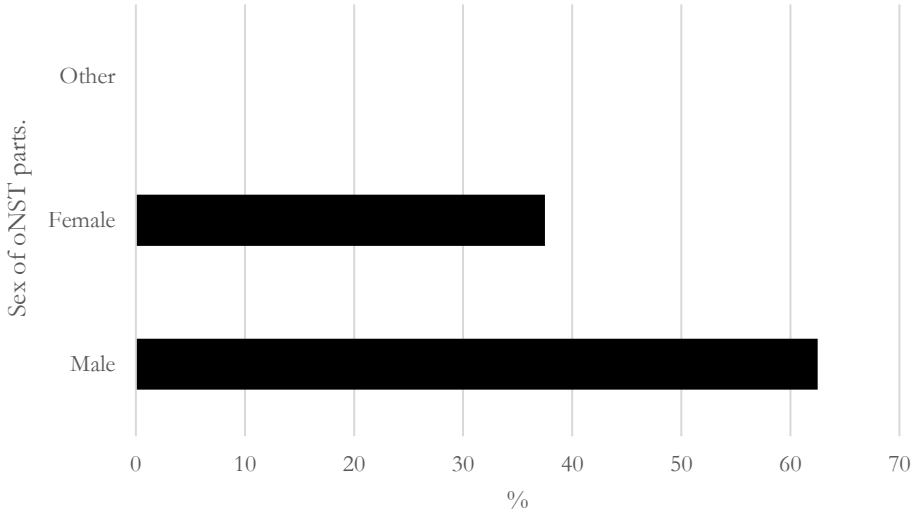


Figure 15. The sex of the participants of the oNST

For 46% of respondents (n = 11), the Introduction to Coaching Football award was the highest qualification held, followed by the UEFA C Licence award (25%), with the remaining 29% of respondents (n = 7) possessing a range of other coaching awards (Figure 16).

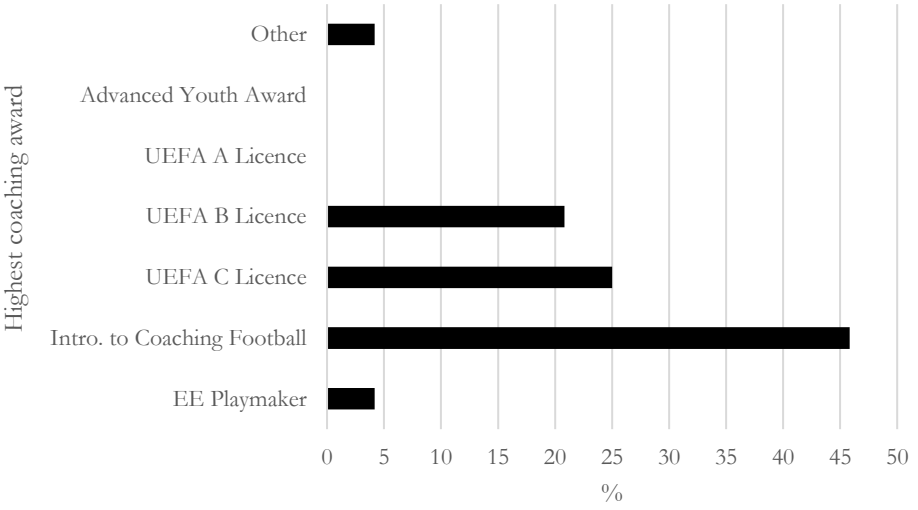


Figure 16. The highest football coaching qualification held by participants of the oNST

The number of years coaching experience (Figure 17) was evenly spread over the five categorised responses via the oNST survey, with most participants (38%) stating that they had been coaching for between 0-2 years (n = 9), with the remaining participants stating that they had been coaching

between 3-5 years (25%), and 6-8 years (21%). Only two participants (8%) stated that they had been coaching between either 9-10 years or over 10 years.

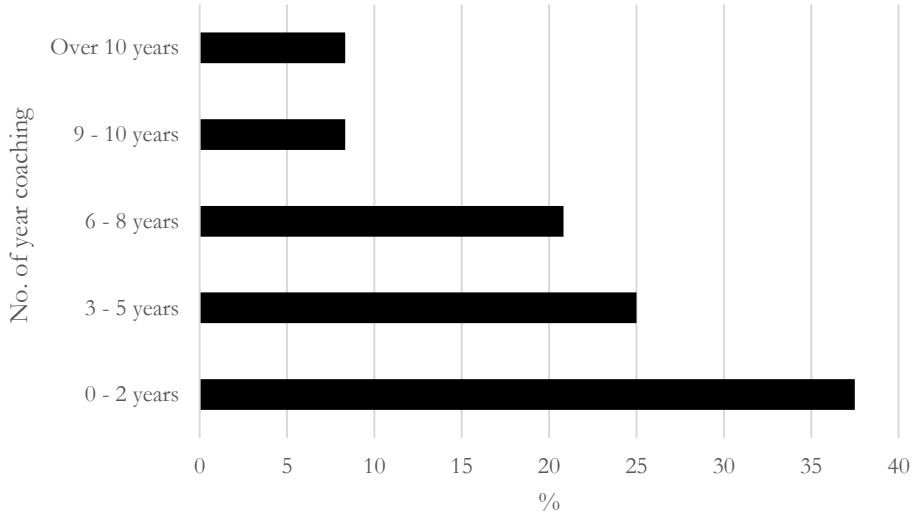


Figure 17. Number of years coaching experience of oNST participants

The majority (50%) of respondents stated that they only coached female players, and further analysis suggested that 96% of participants (n = 23) had experience of coaching females (Figure 18).

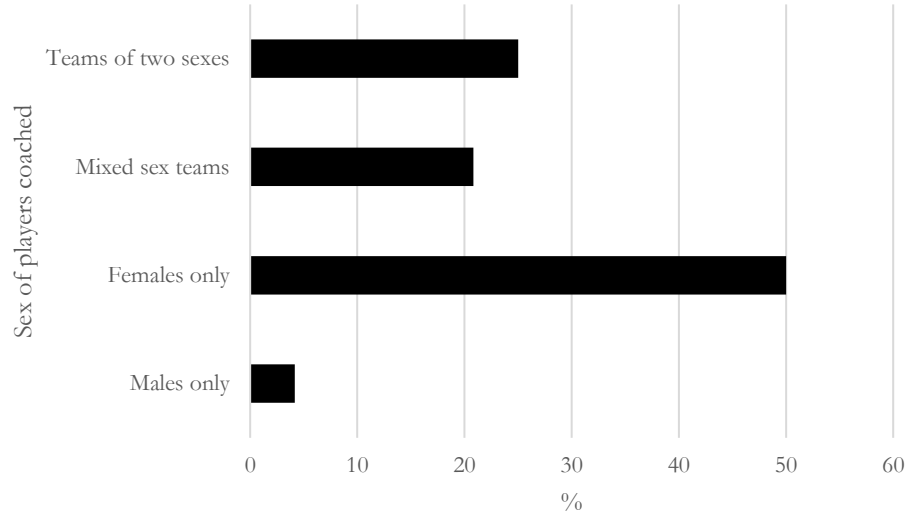


Figure 18. The biological sex make-up of the teams coached by participants of the oNST

Most of the participants from the oNST coached groups aged between U13-U16 (46%) or U10-U12 (33%). Other coaches identified that they coached U7-U9 (17%) with only one participant coaching 17+ age groups. Zero respondents stated that they coached 'other' age groups (Figure 19).

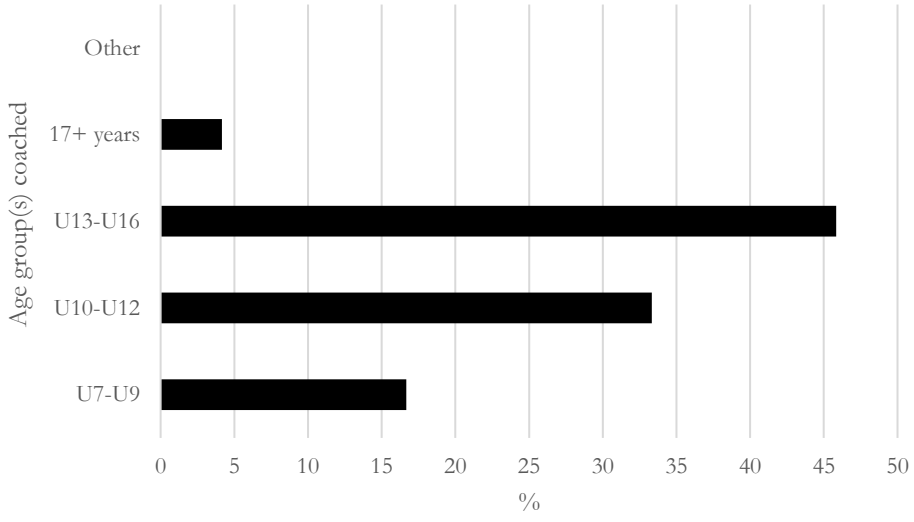


Figure 19. The age groups that the participants of the oNST coach

4.3.1.2 inNST

Of the respondents included in oNST analysis, four participants (17%) stated that they wished to undertake the inNST. However, none of these participants responded to the researcher's contact to arrange the resultant session. Therefore, no inNST sessions took place.

4.3.1.3 Question drop-off rate

Out of the 36 participants who began the oNST, 81% (n = 29) started answering the embedded questions. One participant was discarded at this point as they only answered the consent page and did not complete anything further. The response rate decreased to 67% (n = 24) after the first three questions, which focused on participants' ratings of their knowledge, confidence, and perceptions of NSTs. There was a general decline in response rates throughout the oNST, beginning with question four, the first demographic question. Of the 67% participants (n = 24) who completed the initial questions before the information about specific screens (questions 1-9 inclusive), only two did not proceed to the knowledge-based questions (questions 10-25 inclusive).

Spearman's rank-order correlation was used to assess the relationship between progress through the oNST (question number) and question response rate among 35 participants. The analysis revealed a strong, negative correlation between progress through the oNST (question number) and question response rate ($\varrho = -0.938$, $p < 0.001$). This indicates that as coaches progress through the oNST, question response rate tends to decrease, and this relationship is statistically significant (Table 16 in Appendix 19). A response rate of 81% was obtained for question 1, decreasing to 44% by question 17 (note, the final question, Question 36 was discounted as this was an optional question). The overall reduction in question response rate during the oNST was 39% (Table 17 in Appendix 20).

As mentioned, there was a significant negative correlation between the question number and the percentage of questions answered by the sample group, indicating that the further participants progressed through the oNST, the less likely they were to complete the oNST questions. Additionally, there was a notable drop-off between questions 16 and 17, where three participants closed the oNST and did not continue. Among the 16 participants (44%) who reached question 17, all 16 participants completed the remaining questions, excluding some optional questions about barriers to an inNST (questions 34 – 36 inclusive).

4.3.2 Knowledge, confidence levels and perceptions of grassroots coaches pre- and post-oNST

Prior to undertaking the education section of the oNST, 36 coaches ranked their knowledge of NSTs with a mean of 2.62 out of 10. Adjusting this mean to only account for the 16 coaches who rated their knowledge both pre- and post-oNST resulted in a very slight increase in mean score (2.69). The mean rating post oNST = 6.06 (Table 18 in Appendix 21). To evaluate whether there was a significant difference between participants' pre-oNST and post-oNST knowledge rating scores, a Related-Samples Wilcoxon Signed Rank Test was conducted. The analysis revealed a significant difference between the pre-oNST ($M = 2.69$, $SD = 2.02$) and post-oNST ($M = 6.06$, $SD = 1.52$) scores, $W = 134.00$, $Z = 3.449$, $p < 0.001$. The positive Z-value and the p-value less than 0.001 indicate that there was a statistically significant improvement in coaches perceived knowledge level of NSTs post oNST (Figure 20). The effect size for this test was $r = 0.86$, which suggests a large effect according to Cohen's (1988) criteria. These results support the hypothesis that the oNST was effective in enhancing participants' self-perceived knowledge of NSTs.

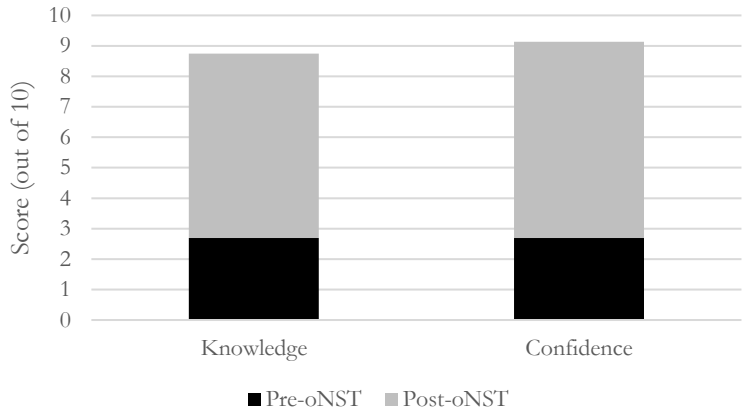


Figure 20. The self-perceived knowledge and confidence levels off participants pre- and post- oNST

As well as coach-perceived knowledge of NSTs, analysis was conducted on the responses to the questions posed in the education section of the oNST. Questions 10-24 of the oNST were a mixture of yes/no questions, open questions and multiple-choice questions. In total, 80% of answers were adjudged to have been answered correctly (231 correct answers from 289 responses). Table 15 details the correct answers per question.

Table 15. Correct answers on the oNST education section

Qu No	Qu topic focus	Type	Total answers	Correct (count)	Correct (%)
Qu10	Score AR 1?	Yes / No	22	19	86.4
Qu11	Score AR 2?	Yes / No	22	19	86.4
Qu12	Score SLHD 1?	Yes / No	21	21	100.0
Qu13	Score SLHD 2?	Yes / No	21	20	95.2
Qu14	SLHD LSI Qu	Yes / No	21	12	57.1
Qu15	Score mTJA 1?	Yes / No	19	17	89.5
Qu16	Score mTJA 2?	Yes / No	19	11	57.9
Qu17	Why AR not scored?	Open	16	16	100.0
Qu18	Why AR not scored 2?	Open	16	11	68.8
Qu19	LSI Qu	Multiple choice	16	11	68.8
Qu20	LSI outcome Qu	Yes / No	16	15	93.8
Qu21	Why mTJA not scored 1?	Open	16	16	100.0
Qu22	Why AR not scored?	Open	16	4	25.0
Qu23	Naming valgus	Open	16	12	75.0
Qu24	Why SLHD not scored?	Open	16	16	100.0
Qu25	AR outcome Qu	Open	16	11	68.8
		Totals/means	**289**	**231**	**80.2**

Open answers (questions 17, 18, 21, 22, 23, 24, 25) were analysed for key terms such as "hands move from hips". Analysis found that open questions had a lower percentage of correct answers compared to closed questions (76.8% vs 81.7%). Moreover, this average correct answer rate was below the average correct answer rate for all questions answered during the oNST (Figure 21). However, out of the three questions that received <60% correct answers, two (questions 14 and 16) were yes/no questions. Question 22 (open) received the lowest number of correct answers (25%). The findings from the Mann-Whitney U test indicate that there is no statistically significant difference in the performance on open versus closed questions based on the percentage of correct answers (Table 22 in Appendix 22). Specifically, the p-value of 0.837 suggests that the distributions of correct answers for open and closed questions are not significantly different. This outcome aligns with the standardised test statistic (0.214), which is close to zero, further indicating a lack of significant difference between the two types of questions.

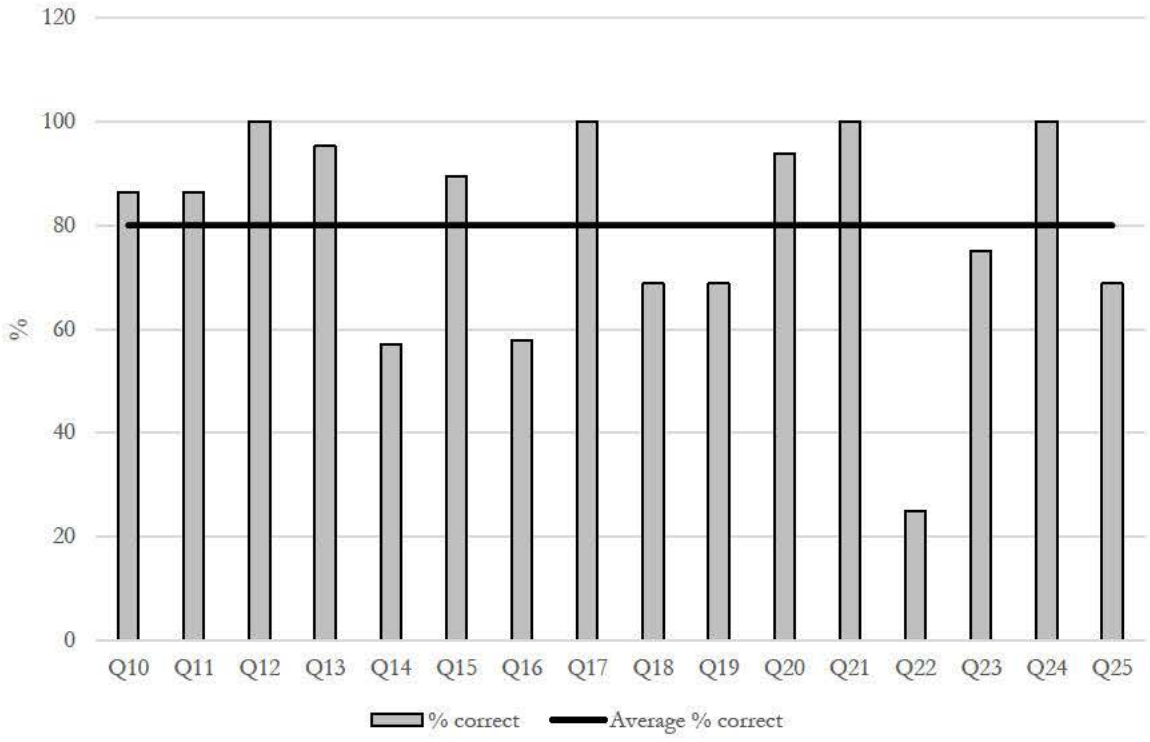


Figure 21. The percentage of questions answered correctly, per question, during the oNST

Coaches also ranked their perceived confidence levels pre- and post-oNST 'education section'. Data was adjusted so only coaches who rated their confidence both pre- and post-ONST education section were included in analysis (Table 19 in Appendix 21). The analysis revealed a significant difference between the pre-oNST (M = 2.69, SD = 2.05) and post-oNST (M = 6.44, SD = 1.73) scores, W = 134.00, Z = 3.430, $p < 0.001$. The positive Z-value and the p-value less than 0.001 indicate that there was a statistically significant improvement in coaches perceived confidence levels of delivering an NST post oNST (Table 21 in Appendix 22).

Coaches' perceptions of using an NST also improved due to undertaking the education section of the oNST. Prior to the intervention and adjusted to exclude coaches who did not complete both the pre- and post-oNST question, 56% of coaches (n = 9) reported that they had a 'neutral' perception of using an NST with their players. Post education section of the oNST, 69% of respondents (n = 11) stated that they had a 'positive' perception of using an NST with their players (Figure 22). Of note, where one coach reported a negative perception of using NSTs post oNST, analysis of unrelated open questions found that the participant highlighted that this answer was posted in error.

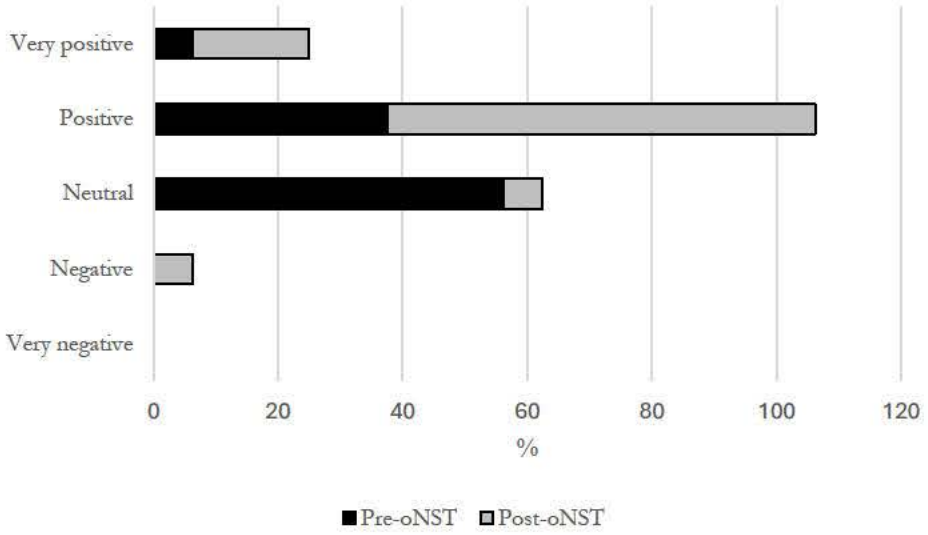


Figure 22. The perceptions of oNST participants regarding NST use, pre- and post- oNST

Supporting this positive shift in coaches' perceptions of NSTs post oNST, 15 coaches (94%) had a positive ('agree' or 'strongly agree') view on the beneficial use of NSTs with players (Figure 23).

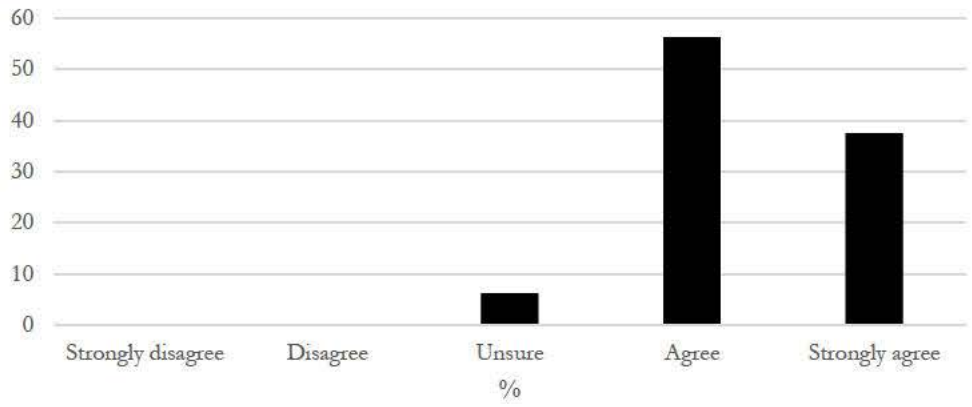


Figure 23. Coaches' perceptions of the beneficial use of NSTs post completion of the oNST

4.3.3 Barriers and facilitators for the successful adoption and implementation of an online and/or in-person CPD session in grassroots adolescent female football

4.3.3.1 Barriers

Of the 16 coaches who progressed to the end of the educational section of the oNST, 75% (n = 12) stated that they were not interested in partaking in the additional inNST (note – the four coaches who stated they did want to undertake the inNST appear to have completed the remaining questions, and these are included in the below analysis). Selecting pre-populated answers, the most popular barrier 'preventing' the coach from partaking in the inNST were 'Lack of time – due to outside of football responsibilities', selected by 38% of respondents (n = 6). In addition, a further two coaches cited any time barrier - Travel time to training event – as the main barrier preventing involvement in the inNST. Finally, the third 'time' option - 'I already spend too much time doing football-related things' was also selected by a further two coaches. Therefore, in total, time-related barriers accounted for 63% (n = 10) of responses when coaches were asked what the largest barrier was preventing them from undertaking the inNST (Figure 24).

However, with a similar response rate to lack of time due to responsibilities outside of football (n = 5), 25% of coaches stated that they did not need to attend the inNST as the oNST 'taught me everything I need to know'. The only other two barriers noted were cost of travel to training event and 'lack of confidence I could perform it [the NST] correctly', both being selected by one respondent (6%).

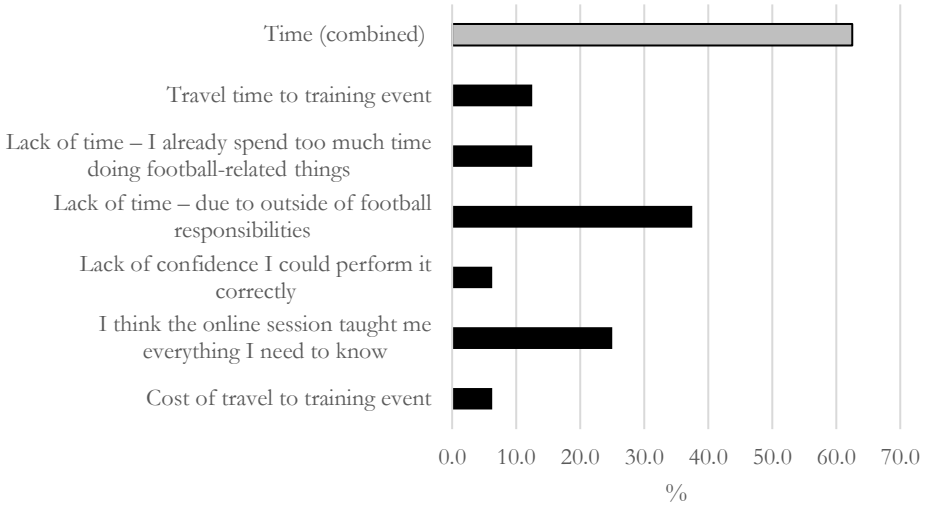


Figure 24. Perceived barriers to undertaking the inNST by participants who completed the oNST

Of note, no coach states that any of the following barriers would prevent them from attending the inNST.

- Accessibility - Limited health (i.e. physical or emotional illness, injury or disability)
- Lack of buy-in (club)
- Lack of buy-in (players and parents)
- Lack of facilities at the club (equipment)
- Lack of facilities at the club (space)

4.3.3.2 Facilitators

The main selected facilitator for attendance at the inNST tool was 'a session local to me' which was selected by 53% of respondents (n = 8). The only two other facilitators that coaches agreed would aid attendance at the inNST was if the CPD session either was mandated by their club (27%) or by the governing body (20%). Taken together, the theoretical mandated need to attend the inNST was a driver for 47% (n=7) of respondents (Figure 25).

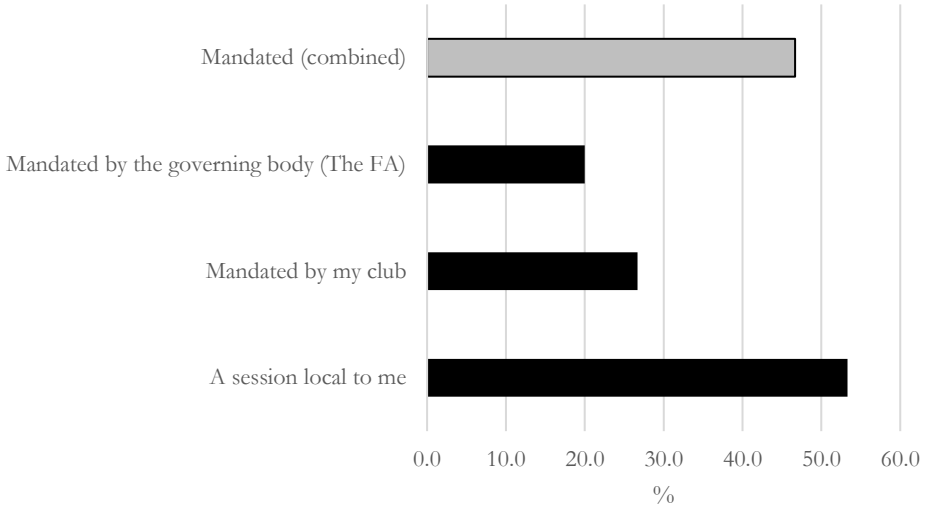


Figure 25. Perceived facilitators for the inNST by Participants of the oNST

Of note, coaches did not find that facilities (either space or equipment), other coaching peers undertaking the training, or a different delivery format was a prominent facilitator that would aid attendance on the inNST.

Coaches were given the opportunity to highlight facilitators by way of an open question (question 31). Analysis by way of key terms identified during the open questions (where 14 coaches provided meaningful text), found terms related to the locality of the session to be the most common answers, with 36% of responses outlining the time saving facilitator of sessions local to them (Figure 26).



Figure 26. Facilitators for further NTS CPD, outlined by way of open question

By way of an open question, participants were also given the opportunity to identify any additional facilitators that would aid implementation of the NST at their club (question 33). Of the 15 responses, only seven (47%) were deemed to provide useful information (with eight responses being a mixture of 'n/a', 'no'). The common adoption of the NST among industry (other clubs etc.) was the main driver that would aid implementation of the NST according to 43% of coaches (Figure 27).



Figure 27. Facilitators to assist with the implementation of NSTs within in the industry

4.4 Discussion

This study aimed to examine knowledge, confidence, and perceptions following participation in an online and/or in-person NST CPD session for coaches of grassroots adolescent female football. Additionally, it aimed to identify the barriers and facilitators influencing the successful implementation of a NST in this context. The discussion will ultimately evaluate the effectiveness of a blended CPD approach for coaches working with adolescent female footballers in grassroots football. As pilot data, these findings are not intended to generalise widely but instead provide early insight into the practical deployment and coach-led implementation of the screening tool and CPD session.

4.4.1 Knowledge, confidence and perceptions (Effectiveness)

A main finding from the study was that, as hypothesised, the oNST significantly improved the self-reported knowledge and confidence levels of grassroots football coaches of adolescent female footballers, with self-reported values increasing from 2.69 and 2.69 to 6.06 and 6.44 out of 10 respectively. While the significant improvement in both perceived knowledge and confidence demonstrates a positive aspect to undertaking the oNST, this result should not be surprising given the dearth of knowledge regarding NSTs in the industry (Chapter 3), coupled with the low self-reported starting points for knowledge and confidence identified by coaches. It is argued that improving an individual's self-reported level of knowledge on a subject can be more significant and easier if their initial self-assessment score is at the lower end of the scale (Dunning, 2011). This is potentially due to the Dunning-Kruger effect, a cognitive bias where individuals with low ability, expertise, or experience in a particular domain tend to overestimate their knowledge or competence. Conversely, those with higher levels of ability or knowledge often underestimate their own competence relative to others (Dunning, 2011). In this instance, as coaches begin to acquire more information and understanding of NSTs, they experience a significant shift in their self-perception, resulting in a noticeable increase in their self-reported knowledge and confidence levels (Dunning, 2011). Moreover, from an andragogical perspective, for individuals with a low starting point, the initial knowledge gaps are typically larger and more apparent. Therefore, targeted instruction such as the oNST could lead to quick and substantial improvements, as coaches will develop a broader range of basic NST concepts and skills initially. This rapid progression could significantly boost coaches' confidence and self-reported knowledge (Vygotsky, 1978). While increased confidence can be empowering, it may also risk overconfidence, particularly if coaches overestimate their ability to apply nuanced screening techniques without supervision. The Dunning-Kruger effect is relevant here, describing how individuals with limited expertise may overrate their competence. Although not directly measured, the oNST may have contributed to such effects by increasing perceived confidence, which could be misinterpreted as mastery.

Crucially, confidence should not be viewed merely as an outcome of increased knowledge but as a mediator influencing how that knowledge is applied. Bandura (1997) defines self-efficacy as the belief in one's capacity to organise and execute actions needed to manage specific tasks. In this study, the rise in coach confidence following the oNST likely enhanced self-efficacy, making coaches more willing to trial screening tools with players. Feltz et al. (2008) argue that coaching efficacy is central to how confidently coaches feel in influencing athlete development. Therefore, by enhancing both knowledge and confidence, the oNST may have increased the likelihood that coaches would apply what they had learned, rather than leaving the content unpractised.

The confidence shift observed in this study likely drew on several sources of efficacy beliefs. According to Bandura (1997), mastery experiences, vicarious experiences, verbal persuasion, and emotional states all contribute to self-efficacy. The oNST, through its structured design, correct-answer feedback, and accessible explanations, likely provided mastery experiences that reinforced coaches' belief in their competence. The immediate feedback loop also helped consolidate correct answers, boosting both achievement and confidence (Schunk & DiBenedetto, 2020). Thus, while overconfidence remains a potential concern, the oNST's design appears to have supported the development of appropriate self-efficacy needed for applied coaching practice.

Away from the self-reported scales, there is evidence that the oNST improved coach knowledge of NSTs. By reviewing the answers to the education section of the oNST (Table 15) respondents answered 81% of embedded questions correctly. In total, 57% of the questions in the oNST education section were closed questions (yes/no or multiple choice). Research suggests that it is generally easier for participants to answer closed questions correctly during an online training session, compared to open questions, as closed questions provide specific options for answers, making it simpler for participants to recognise the correct answer even if they are not fully confident in their knowledge (Little & Bjork, 2015; Roediger & Marsh, 2005). This format can cue

participants towards the correct answer through recognition rather than recall, which requires less cognitive effort (Little & Bjork, 2015; Roediger & Marsh, 2005). Notably, even when correct answers arise partly through recognition, they can still serve to reinforce feelings of competence and confidence. According to Deci and Ryan (2000), competence is a core psychological need in self-determination theory, which underpins intrinsic motivation. When coaches feel more competent and confident, they are more likely to engage further with the topic and invest in applying the knowledge practically. Therefore, even if closed-question formats make success easier, that success can build perceived mastery, which encourages future effort and learning persistence (Ryan & Deci, 2007). Conversely, open questions require participants to generate answers independently, which demands a deeper understanding and the ability to recall information without prompts, making them inherently more challenging (Freeman et al., 2014; Pashler et al., 2008). Given the use of closed questions in its design, it therefore may not be surprising that the oNST resulted in an 80% success rate in terms of correct answers. Moreover, as findings of this study indicate that closed questions have a higher percentage of correct answers compared to open questions (81.7% vs. 76.8%), the notion that the oNST demonstrates an enhancement in coaches' knowledge may be flawed due to the predominant use of closed questions during the oNST.

Conversely, statistical analysis did not find a significant difference between the percentage of correct answers when comparing the closed and open question response rates. Additionally, three of the seven open questions (questions 17, 21, 24) resulted in an 100% correct answer response rate, whereas only one closed question (question 12) achieved the same. Moreover, although an open question (question 22) resulted in the lowest correct answer rate (25%), further analysis highlights a potential limitation of the question itself. Most participants cited that the specific screen (AR test) was not scoreable due to the foot not contacting the ground. While the intended reason for not scoring the test was the movement of the hands from the hips during the AR test, the participants' reasoning (foot not contacting the ground) is also a valid reason not to score the

AR (McCunn et al., 2017). Therefore, although their reasoning was incorrect, the outcome (the test not being scored) was correct. Additionally, it is possible that the video, filmed in the frontal plane, was not of high enough quality for participants to see that the foot did, in fact, contact the ground, thus prompting participants to consider alternative reasons for not scoring the AR test.

Finally, as noted earlier (question 22), although most questions in the education section of the oNST were closed questions, these responses align with the real-world application of the screens used in the NST as coaches would be observing movements and deciding whether a specific screen should be measured (i.e. yes or no). Consequently, the coaches' self-reported increases in both knowledge and confidence levels after the oNST, combined with the high overall percentage of correct answers regardless of the question type, support the argument that the oNST education section is effective in enhancing coaches' knowledge and confidence in using NSTs. The relationship between confidence and competence in this study's context appeared complex and merits further investigation, as not all coaches who reported high confidence answered all questions correctly. High competence does not always correlate with high confidence. For instance, a coach may possess extensive knowledge and skills but still lack confidence due to previous negative experiences. Conversely, a confident coach might excel in motivating and engaging athletes, even if their technical competence is still developing. Although this study cannot directly measure the correlation between confidence and competence, the high achievement rates for each question suggest that coaches are likely competent at assessing players on specific assessments. Furthermore, the low attendance at the inNST (discussed below) can be attributed to coaches believing that the oNST provided them with sufficient knowledge, thereby eliminating the need to attend the inNST. This supports the idea that the oNST boosts coaches' confidence levels. However, as previously mentioned, this increased confidence may not necessarily correspond to the coaches' competence in correctly delivering and scoring the screens. This potential disparity between confidence and competence is further highlighted by the fact that only

two participants (13%) who attempted all questions achieved 100%. This indicates that, even when excluding open-ended questions, 76% of respondents answered at least one closed question incorrectly.

Compared to more discussion-based CPD sessions, such as in-person sessions, a strength of the oNST is the immediacy of feedback to questions as well as question repetition contained within the oNST. Feedback is most effective when it is immediate because it helps students understand their mistakes and correct their misunderstandings while the learning material is still fresh in their minds. This timely intervention helps solidify correct information and prevent the reinforcement of incorrect knowledge, leading to better retention and understanding (Shute, 2008). Moreover, immediate feedback helps sustain learner engagement and motivation by providing quick validation and corrective guidance (Van der Kleij et al., 2015). When learners can immediately see the results of their efforts, they are more likely to stay motivated and continue engaging with the material, which fosters a more dynamic learning environment. Additionally, the multiple questions based on each specific screen enhances retrieval practice, as it involves the repeated testing with feedback, which helps improve long-term retention of information. This practice allows learners to apply the feedback they received, thus reinforcing their learning through repetition and active engagement with the material (Karpicke & Blunt, 2011). These points support the argument that the oNST shows promise as a delivery model for NST CPD, though broader validation is needed.

Another finding from this study was that undertaking the oNST resulted in a positive shift in coaches' perceptions of NSTs, with most coaches moving from a neutral (56%) to a positive (69%) opinion (with 88% of coaches selecting either 'positive' or 'very positive'). This positive shift is unsurprising given the correct answer achievement rates in the educational section. Obtaining correct answers could increase the coach's self-efficacy in the knowledge and use of NSTs. Bandura's theory of self-efficacy posits that when students experience success, they build

confidence in their abilities, which in turn fosters a more positive attitude towards the subject matter (Bandura, 1997), thereby potentially explaining the positive shift in attitudes towards NSTs in this instance. Moreover, the reciprocal relationship between competence and interest is emphasised in the Expectancy-Value Theory (EVT) of achievement motivation (Eccles & Wigfield, 2002). The EVT suggests that students who perceive themselves as competent in a subject are more likely to value and enjoy that subject, which enhances their motivation and engagement. When students feel they are good at something, they are more likely to invest effort and persist in the face of challenges, leading to a cycle of improvement and positive attitude (Eccles & Wigfield, 2002). There is therefore a circular argument that coaches undertaking the oNST will, on average, score highly in the knowledge-check questions, thereby increasing their perceived self-efficacy, which in turn will increase positive perceptions to using NSTs, which will result in coaches dedicating more time and effort into using and researching NSTs in the future. This argument supports the potential utility of the novel oNST developed in this study, particularly in shaping perceptions and self-reported outcomes.

4.4.2 Barriers and facilitators for the successful adoption and implementation of an online and/or in-person CPD session in grassroots adolescent female football (Reach / Adoption / Implementation).

Perceived lack of time was shown to be the most common barrier highlighted by coaches when asked if they wanted to undertake further CPD on NSTs (the inNST), with 'time' collectively being mentioned in 63% of the responses. This data is generally consistent with results in Chapter 3, which showed that youth football coaches ranked lack of time as the third most prevalent barrier to NST implementation. Interestingly, Chapter 3 found that lack of facilities was ranked as the second most influential barrier to NST implementation, yet the results in this chapter note that no respondent suggested lack of facilities combined (encompassing equipment or training space) was

a barrier to undertaking further NST training or NST implementation. Chapter 3 found 87% respondents had limited knowledge of NSTs. Additionally, Chapter 3 revealed through a survey that coaches identified knowledge as the primary facilitator for NST implementation. It can be argued that participating in the oNST enhances coaches' awareness and understanding of NSTs, allowing them to recognise that implementing these strategies does not require significant equipment. This recognition is important because sports typically allocate funds to facilities rather than support services and equipment, such as sports science tools (Green & Houlihan, 2005). Without prior knowledge of NSTs, many coaches might assume that implementing the CPD product would be cost-prohibitive due to perceived equipment needs. Consequently, for those now familiar with the NST format, lack of time might be proposed as an even higher-ranked barrier. Time was consistently also noted as a barrier to NST implementation via interviews (Participant 1, Participant 3, Participant 4 Participant 7, Participant 8) and has been found to be a barrier to implementation of IPEPs and the FIFA 11+ (Junge et al., 2011; O'Brien & Finch, 2014). Supporting our findings, time limitations has been found as a primary barrier faced by volunteer coaches in youth sports as many volunteer coaches often have full-time jobs and family responsibilities, leaving limited time for additional training and development activities. This lack of time impacts coaches' ability to attend coaching courses, workshops, and other professional development opportunities (Wiersma & Sherman, 2005). It is important to distinguish between this time constraint - for acquiring NST knowledge – rather than the time needed to implement and maintain NSTs within clubs. The problem of time as a barrier has also been highlighted in research, which found that the time required to engage in formal coach education programmes was a significant deterrent for many coaches, especially those who are volunteers (Nelson et al., 2006). The study suggested that flexible learning options, such as online courses or modular programmes, could help mitigate this barrier by allowing coaches to engage in professional development at their own pace and convenience.

Among those who completed the oNST, a lack of motivation was not commonly cited as a barrier, though this may not reflect views across all grassroots coaches. One reason for this could be the voluntary nature of enrolment in the research project as coaches who voluntarily enrol in training are more motivated to complete the training and are more receptive to the messages contained within (Søvik et al., 2017). Moreover, perceived complexity and relevance of CPD can also affect motivation. Volunteer coaches might view a CPD programme as either too advanced or irrelevant for their coaching responsibilities, which could lead to a decreased interest in seeking additional educational opportunities (Nelson et al., 2006). It is therefore possible that the high attainment rate in the oNST allowed participant coaches not to view the oNST as too complex and thus would not suffer from a lack of motivation to complete similar training. Moreover, as motivation to complete training is linked to relevance of the content to coaching practice (Nelson et al., 2006), the lack of motivation being cited as a barrier to the oNST could point to an indirect measure of the oNSTs relevance to the participant's coaching practise.

Unexpectedly, the only other barrier highlighted by numerous coaches was, it could be argued, not a barrier – that the educational section of the oNST 'taught me everything I need to know'. This result, therefore, not only indirectly emphasises that time is the main potential barrier to NST implementation, but it also further supports the notion of the effectiveness of the oNST in developing the knowledge, confidence and positive perceptions of NST's of coaches.

The main facilitator noted was that coaches believed participation in future NST's would increase if the sessions were held at a location convenient for them. The facilitator tallies with the main barrier reported in this present study – time. Supporting these findings is research that has consistently shown that logistical convenience, including the location of CPD sessions, plays a crucial role in the decision-making process for coaches. Coaches are significantly more likely to attend training and educational workshops that are held within a convenient travel distance from

their primary place of work or residence. The closer the location, the lower the barriers related to travel time, cost, and logistical arrangements, which are substantial considerations for coaches who often have demanding schedules (Nelson et al., 2013). Further research explored the factors affecting coaches' attendance at CPD sessions. Factors affecting coaches' attendance at CPD sessions indicated that geographical proximity was a major factor, alongside other considerations such as the relevance of the session content and the reputation of the facilitators (Cushion et al., 2003). Coaches reported that sessions held closer to their home or work locations were more accessible, reducing the need for overnight stays and minimising disruptions to their regular coaching duties. This accessibility was crucial for those working with tight budgets and limited time, thus directly influencing their likelihood of participation (Cushion et al., 2003).

A further facilitator cited that would encourage further training and implementation of NSTs is stakeholder buy-in (players, parents, club etc). Research finds the support and encouragement from players and parents significantly impact coaches' motivation to engage in CPD activities. When players demonstrate a desire for improved training and parents show an active interest in the coach's professional growth, it reinforces the importance of CPD. This external validation helps coaches feel valued and recognised, motivating them to invest time and effort into furthering their education (Mesquita et al., 2015). Furthermore, the role of the club is paramount in fostering a culture that prioritises professional development where clubs that actively promote CPD and provide resources and incentives for coaches to participate tend to see higher attendance rates at training sessions (Wright et al., 2007). When clubs institutionalise CPD as part of their development strategy, it signals to coaches that ongoing education is essential and supported. This institutional backing can include funding for courses, flexible scheduling to accommodate training, and public acknowledgment of coaches' efforts (Wright et al., 2007). However, each football club in England club has the autonomy to choose its own structure, as the FA does not prescribe or mandate a specific format (The Football Association, 2015). Consequently, coaches' perceptions

regarding the necessity of club support for a facilitator in CPD opportunities, as well as the club's capacity to institutionalise CPD within their development strategy, will vary significantly between clubs.

Focusing on facilitators of NST implementation itself, research finds that coaches are more likely to implement new knowledge and techniques acquired during CPD when they receive positive feedback and support from their clubs and immediate stakeholders (Stoszkowski & Collins, 2016). This supports the notion that coaches need to be internally motivated to undertake CPD NST sessions. However, when combined, 'mandated' to undertake further CPD training in future (by club and NGB) was a significant facilitator highlighted by 47% of coaches. The importance of NGB buy-in is evidenced by research demonstrating an awareness of the 11+ in 80% of coaches where the programme had been promoted by the NGB (Junge et al., 2011). This suggests that there is also an external motivational component felt by coaches. Although it is reported that the desire for higher-level coaching positions, which typically offer better financial incentives and greater prestige, drives many coaches to engage in continued education (Cushion et al., 2010), this maybe not relevant to a volunteer coaching population. However, supporting the external motivation of volunteer coaches to undertake CPD, it could be argued that external validation and recognition significantly influence coaches' decisions to seek further education. Coaches who achieve advanced certifications or complete prestigious or novel training programmes often receive acknowledgment and respect from their peers, players, and club. This external recognition can boost their professional reputation and provide a sense of accomplishment and status within the coaching community (Cushion et al., 2010). Notwithstanding, motivation to undertake CPD in a coaching context is often individualised and confused, as many coaches struggle to identify their developmental needs or to suggest meaningful CPD activities (Nash et al., 2017). Moreover, although research has shown an increased in awareness of the FIFA 11+ post intervention by the NGB, the suggested benefits of mandated CPD programmes (i.e. improved retention thus raising

professional standard), has been shown to not consistently improved competence in all professions (Neimeyer et al., 2012).

4.4.3 Effectiveness of a blended approach to CPD for grassroots football coaches of adolescent female footballers (Reach / Effectiveness)?

There are several ways to assess the effectiveness of the blended approach to CPD for grassroots football coaches of adolescent female players. One argument is that the blended approach was not very effective, which can be supported by various reasons. First, the low response rate (2%) for the oNST suggests that most coaches are not interested in the subject matter and/or participating in the blended CPD format. Additionally, the significant negative correlation indicates that as participants progress through the oNST, they are more likely to discontinue it, thereby questioning the overall effectiveness of the oNST learning methodology. Finally, 75% of oNST participants stated that they did not want to complete the inNST, and none of the 25% who expressed interest in the inNST completed the full blended CPD session. This point is surprising given the fact that 71% of coaches stated that they would rather partake in in-person, rather than online CPD (Chapter 3). Research, discussed in Chapter 2, outlines that coaches are becoming more open to using online support mechanisms to enhance their learning experience (Leeder et al., 2021), a trend that has been accelerated by the COVID-19 pandemic (Stoszkowski & Collins, 2022). However, sports coaches value in-person CPD due to the ability to interact with peers, creating more opportunities for coaches to exchange ideas with peers during practical or in-person CPD (Ciampolini et al., 2019). The observations of Ciampolini et al., (2019) can be described by the Communities of Practice (CoP) theory (Wenger, 2000). Volunteer sports coaches often form informal CoPs, where they exchange knowledge, share experiences, and develop their coaching skills. CoPs are characterised by three elements: domain, community, and practice. In the context of volunteer sports coaches, the domain is the shared interest in sports coaching and athlete

development. The community is the network of coaches who interact regularly, sharing insights and supporting each other. CoP offers opportunities for volunteer coaches to construct meaning through real-world practice, interact with peers, and apply knowledge in practical contexts, thus bridging the gap between theory and practice more effectively than traditional educational methods. This aligns with research indicating that coaches often learn most effectively from their interactions with other coaches and through practical experiences (Stoszkowski & Collins, 2014). Further, a survey revealed that coaches perceive in-person CPD as more effective in fostering a deeper understanding of coaching concepts and techniques (Mallett & Dickens, 2009). The tactile and demonstrative elements of in-person training can enhance learning, especially when complex motor skills (such as NST assessments) or strategies are involved. The physical presence of instructors and peers can also motivate coaches to stay engaged and committed to the learning process.

Given the preferences of coaches highlighted above, and the practical nature of the learning content involved, especially in the inNST, it is therefore surprising that the blended CPD approach appears to be not effective. It is suggested that the reasoning behind this finding could be linked the coach-perceived barriers to NST training and implementation, namely time. Students in blended learning environments that incorporated online components performed better in terms of learning outcomes compared to those in purely face-to-face settings (Means et al., 2010). Online learning environments facilitate asynchronous communication, allowing participants to engage in discussions and complete assignments without the constraints of synchronised schedules. This aspect of online learning can lead to more efficient use of time, as learners can participate in educational activities at moments that best fit their individual schedules. The ability to revisit and review materials as needed further enhances the time efficiency of the online section (Hrastinski, 2008; Stoszkowski & Collins, 2022). As such, given the time pressures acknowledged as a major barrier, coaches may have had time to complete the oNST section, but not the inNST, even if they

had the desire to do so. The notion is supported by the fact that coaches named locality as the number one facilitator that would enable them to partake in the inNST. Another factor contributing to the lack of inNST participants could be linked to coaching experience and coaching awards. In Chapter 3, most respondents (35%) had over 10 years of coaching experience, with 61% having at least six years. In contrast, most oNST participants (38%) had only 0-2 years of coaching experience, and 63% had less than six years' experience. Additionally, most survey respondents held the UEFA C coaching award, while oNST participants generally had the 'Introduction to Football Coaching' award. This suggests that different levels of coaching experience and the highest coaching award obtained may influence coaches' training modality preferences, in that the coaches' who would have been interested in completing the inNST were not interested in completing the oNST, and thus never had the opportunity to progress to the inNST.

Another reason for the potential ineffectiveness of the hybrid NST CPD session could be the effectiveness of the oNST itself. As previously discussed, the oNST has found to be effective as a standalone novel CPD tool, evidenced by statistically significant improvements in self-perceived knowledge and confidence levels among participants, along with positive post-completion feedback. Additionally, participants achieved an average correct answer rate of 81% throughout the oNST. When removing time as a factor (as discussed above), the most common reason cited by coaches for not undertaking the inNST after completing the oNST was the perception that they had already acquired sufficient knowledge. Students who feel confident in their understanding of a topic are less motivated to engage in further learning activities (Bandura, 2018). Additionally, perceived mastery of content significantly reduces the likelihood of students participating in additional educational sessions, as they see little benefit in doing so (Schunk & DiBenedetto, 2020). This is consistent with the findings of Ryan and Deci, (2000), who noted that intrinsic motivation diminishes when individuals perceive no further need for additional engagement, believing their

current knowledge suffices for their goals. Whilst it is acknowledged that coaches in this study may not perceive mastery in the topic area, the success of the oNST, coupled with the barriers outlined above may explain the reduced need for the inNST section of the CPD session.

4.4.4 Limitations

A variety of limitations are acknowledged, the first of which is the lack of 'reach' for the oNST session. However, although only 2% of all emails sent to clubs resulted in participants starting the oNST, it is not known how many of the approximately 1811 emails, or social media posts were received and read by the targeted end user, with research suggesting that up to 77% of unsolicited emails go unread, let alone actioned (Zimmermann, 2013). While the 'reach' of the oNST is low, participant numbers are consistent with similar research. For example, and although research in this area is limited, 21 coaches took part in research investigating an online learning and reflection tool for use by sports coaches (Stoszkowski & Collins, 2022).

Another limitation of this study was the use of the Wooclap platform to host the oNST. While this free platform allowed researchers to collect survey responses without needing specialised programming skills, design skills, or a dedicated Learning Management System, it had some drawbacks. Although the platform required participants to answer all questions, they could bypass questions using the browser's navigation arrows. However, this issue appeared infrequent, as indicated by a steady, negative correlation between question number and response rate, suggesting that participants did not skip questions and then proceed to answer subsequent ones. Additionally, the oNST's use of YouTube clips to demonstrate NSTs and examples was another limitation. The viewing experience for participants could have been improved with more sophisticated video editing, such as incorporating multiple angles to provide a more comprehensive understanding. However, the cost of software and editing tools was prohibitive. Additionally, videos presented

from multiple angles or in high-resolution slow motion might have led participants to subconsciously believe that they would also need advanced recording equipment to effectively evaluate the screens.

A further limitation is selection bias - only those interested in completing the oNST would do so, leading to a higher likelihood of these participants rating the oNST and NSTs more favourably due to their pre-existing positive perceptions of NSTs. However, firstly, pre-oNST knowledge of NSTs is limited (see Chapter 3). Secondly, research into CPD highlights a significant advantage of offering specific and bespoke CPD content, as it allows learners to choose material directly relevant to their practice. This approach is preferable to a mandatory curriculum that may include irrelevant sections (Cushion et al., 2010; Nelson et al., 2013; Stoszkowski & Collins, 2016). Consequently, the selection bias observed here may align with the practical application of modular CPD, reflecting real-world scenarios where volunteer coaches seek out pertinent and impactful learning experiences and informal education.

The final limitation of this study relates to the thoroughness of the assessment of the full hybrid NST CPD session using a modified RE-AIM framework. Due to the lack of participants opting to take part in the inNST, several questions could not be addressed by coaches after the inNST session. These unanswered questions mainly pertain to the implementation and maintenance sections of the RE-AIM framework (Table 11 to 14). Although this is a study limitation, the research design would have allowed coaches to discuss implementation and maintenance barriers and facilitators during the inNST session. This approach aligns with previous research suggesting that coaches prefer working directly with peers to devise solutions and discuss best practices (Deek et al., 2013; Jones & Allison, 2014; Nelson et al., 2013). Furthermore, this limitation indirectly provided insight into coaches' preferences, indicating a preference for online CPD sessions over in-person NST sessions. This preference highlights the importance of offering CPD formats that

align with coaches' needs and preferences, with further research investigating coaches' views on the implementation and maintenance of the oNST suggested.

4.5 Conclusions and practical applications

This research is explicitly framed as pilot work aimed at exploring the feasibility, coach engagement, and practical implementation of a field-based NST tailored for adolescent female grassroots football. Given the absence of existing tools developed for use by coaches in non-elite settings, the study was designed to generate preliminary insights. As such, this pilot project provides a foundation upon which future studies can build, refine, and validate the tool in broader populations and settings. Moreover, this study provides valuable insights into the effectiveness of a novel blended CPD approach for coaches of grassroots adolescent female footballers, particularly focusing on an online and/or in-person NST session. The pilot study demonstrated significant improvements in self-reported knowledge and confidence among coaches following participation in the oNST session. These improvements can be attributed to the low initial self-assessment scores and the subsequent rapid acquisition of fundamental NST concepts, corroborating theories such as the Dunning-Kruger effect. Additionally, the high correct answer rates in the education section of the oNST, in both closed and open formats, further indicate an enhancement in coaches' understanding. It is important to recognise that confidence is not static but dynamic. Research on coaching development highlights that confidence fluctuates depending on the context, past experiences, and ongoing feedback (Nash et al., 2011). CPD designs that include opportunities for ongoing feedback and reflective practice can help maintain and appropriately regulate confidence levels over time. Embedding follow-up activities, peer mentoring, or periodic refreshers as part of the CPD ecosystem can help ensure that initial gains in confidence are sustained and translated into sustained practice change (Gilbert & Trudel, 2001).

The study also highlighted several barriers and facilitators to the successful implementation of a novel NST CPD programme. The most prevalent barrier was the perceived lack of time, a common challenge for volunteer coaches balancing multiple responsibilities. Interestingly, lack of facilities was not deemed a significant barrier post-oNST, likely due to increased awareness and understanding of NSTs. Conversely, logistical convenience and stakeholder buy-in emerged as critical facilitators, emphasising the importance of accessible and locally held CPD sessions, as well as support from clubs and immediate stakeholders in motivating coaches to engage in further training.

Despite these positive outcomes, the study revealed a mixed response to the blended CPD approach overall. While the oNST was effective as a standalone tool, the subsequent inNST was not attended, which is at odds with previous studies suggesting coaches' preference for in-person CPD (Chapter 3). Explaining this, the comprehensive knowledge gained from the oNST may have reduced the perceived necessity for further training. This finding may reflect patterns described in self-efficacy and motivation theories, where perceived knowledge sufficiency can reduce interest in further learning, though this was not explicitly measured here (Bandura, 2018).

The study acknowledges several limitations, including a low participation rate, potential selection bias, and the limitations of the Wooclap platform and video quality used in the oNST. Consequently, a deliberate decision was made to base the mTJA questions on a 'to score' vs 'not to score' approach, without including questions on specific scoring points (i.e. 1 point for thighs not reaching parallel). Additionally, the lack of comprehensive assessment using the RE-AIM framework due to lack of participation in the inNST session presents a challenge in fully evaluating the implementation and maintenance aspects of the blended CPD model.

Overall, the findings suggest that while the novel oNST session effectively enhances knowledge and confidence among coaches, the blended approach may require further refinement to address practical barriers and align more closely with coaches' preferences and time constraints. Future research should focus on exploring more flexible and accessible CPD formats and investigating the long-term impact of these training sessions on coaching practices in adolescent female footballers.

The practical applications of this study are significant for the development of CPD programmes for grassroots football coaches. First, the findings support the use of online training modules as an effective means to enhance knowledge and confidence, particularly for coaches with limited prior exposure to NSTs. These findings suggest that online platforms may offer a useful route for delivering training to some coaches, though wider testing is required before broader implementation.

Second, addressing the time constraints faced by coaches, offering modular and self-paced online training can help mitigate this barrier. Furthermore, ensuring that in-person CPD sessions are held locally can reduce logistical challenges and encourage higher participation rates. Clubs and football associations should consider investing in local training hubs and fostering a supportive environment that values continuous professional development.

Lastly, the importance of stakeholder support highlights the need for engaging players, parents, and clubs in the CPD process. By promoting a culture that values and supports ongoing education, clubs can motivate coaches to pursue further training, thereby enhancing the overall quality of coaching and player development in grassroots football.

Chapter 5: Final conclusions and recommendations

5.1 Introduction

The preceding chapters detailed the design and piloting of an innovative hybrid NST CPD product tailored for grassroots coaches of adolescent female footballers. This hybrid NST CPD product was developed in response to perceived needs identified by a sample of volunteer coaches, enabling them to have a tool to easily identify players with abnormal movement patterns that could increase future injury risk. A cornerstone of this research was the iterative involvement of volunteer coaches throughout the entirety of this research via surveys, interviews, a co-production focus group (Chapter 3), and pilot testing (Chapter 4). When combined with evidence-led research, this coach-centred collaborative approach aimed to ensure the creation of a product that can be effectively implemented in professional practice.

5.2 Evaluating the NST

The RE-AIM framework (Glasgow et al., 1999) is a model used to evaluate health interventions that has also been employed to help guide evaluations of IPEPs in adolescent football (Donaldson et al., 2018; O'Brien & Finch, 2014). The RE-AIM framework helps researchers, practitioners, and policymakers understand not only the effectiveness of a coach education programme but also its feasibility, scalability, and long-term impact, making it a valuable tool for improving coaching practices and development initiatives. This thesis used a modified RE-AIM framework (mainly focusing on reach and effectiveness) as a broad structure to guide its conclusions and recommendations.

5.2.1 Reach

'Reach' can be defined as the percentage and characteristics of coaches from the target population who participate in the education programme. This dimension assesses the extent to which the programme reaches its intended audience as well as assessing the barriers and facilitators to this participation (*What Is RE-AIM?*, n.d.). In this context, the barriers and facilitators discussed below relate to improving participation in the NST in the immediate future.

The overall research presented in this thesis suggests that NST CPD sessions had low reach. The survey results (Chapter 3) indicate that most coaches (87%) were unaware of NSTs before completing the survey, and most had never seen or were unsure if their colleagues used NSTs. These findings show that youth grassroots football coaches have limited knowledge or awareness of NSTs, both in their own practice and among their peers. This lack of awareness is particularly evident in the female game, with only one coach considering movement quality during regular coaching. Comparisons to similar initiatives like IPEPs reveal a similar lack of awareness, such as with the FIFA 11+ programme, which 50% of grassroots coaches had not heard of despite national promotion (Donaldson et al., 2018). Only 19% of youth grassroots coaches were aware of injury prevention strategies or training prior to attending educational workshops (De Ste Croix et al., 2020). The limited reach of similar projects is confirmed by the research in this thesis, which found survey response rates of 5%, with only 2% of all emails sent to clubs leading to participants starting the oNST (Chapter 3 and 4). The low reach reported in literature and documented during this project could be attributed to the limited focus on AMCs in NGB coach education programmes, which prioritise technical skills, contributes to this knowledge gap (Duncan et al., 2022).

The most common age range among participants of the oNST was 35-44 years, with 42% falling into this category. While detailed demographic data for volunteer football coaches in England is

not readily available, the predominant age group within the broader UK coaching population is also 35-44 years, representing 23% of coaches (UK Coaching, 2017). Additionally, 65% of coaches are under the age of 45 (Thompson & Mcilroy, 2017). While the low response rate indicates limited reach, the age distribution of oNST participants aligns with trends in national coaching demographics, suggesting potential relevance to this age group. This is particularly evident when considering that the survey in Chapter 3 reached coaches with a similar average age of 45.1 years. Moreover, a comparable trend is noted for the reach of the oNST in terms of the sex of coaches (male = 63%, females = 38%) with more males completing the oNST compared to females, further reinforcing that the data collected in this thesis is reflective of the typical UK coach (male = 55%, females = 44% - UK Coaching, 2022), thus offering some alignment with typical coach demographics, though generalisability remains limited due to sample size.

In Chapter 3, 61% of respondents had at least six years of coaching experience, with 35% having over 10 years. In contrast, 63% of oNST participants had less than six years of experience, with 38% having only 0-2 years. Additionally, most survey respondents held the UEFA C coaching award, whereas oNST participants typically held the 'Introduction to Football Coaching' award. This suggests that coaches with more experience and higher qualifications, who might have been interested in the inNST, did not engage with the oNST and therefore missed the opportunity to progress to the inNST. Conversely, it could be argued that the oNST appealed to newer coaches, who are potentially keen to acquire the knowledge and skills necessary to establish their credibility and effectiveness in industry, and thus the reach of the oNST could be reevaluated within the parameters of a specific subset of newer/less experienced volunteer football coaches.

Regardless of subsets targeted, it is proposed that the reach of both the oNST and inNST could be improved. The awareness of the FIFA 11+ programme is much higher (80%) in certain countries where the programme has been supported by the NGB (Junge et al., 2011), findings

which underscore the importance of NGB 'buy-in' in increasing the reach of NSTs in youth grassroots football. This collaboration between initiatives and NGBs is one avenue to improve the reach of a project. Additional mechanisms that could improve the reach of the oNST and inNST could include segmented marketing – where identification and segmentation of the target audiences (e.g., age groups, qualification an experience level etc.) develop marketing materials and campaigns tailored to each segment, making messages more relevant (Kreuter et al., 2003). Given the differences between the survey cohort who suggested their preference for inNST sessions and the oNST participants, newer coaches could be specifically targeted to undertake the oNST, where is more experienced coaches may be targeted to undertake only the inNST.

A consistent barrier noted by participants of the oNST, that prevented them from partaking in the inNST was time. Time was also highlighted as a barrier by participants of the survey in Chapter 3. To improve the reach of both the oNST and inNST, accessibility and inclusivity need to be considered. In this context the facilitator noted by potential participants for the inNST mainly focused on the availability of local sessions to reduce the time burden and costs associated with travel. To enhance the reach of interventions, offering diverse time slots and formats, such as weekends, evenings, and alternatives to the oNST, can better accommodate varying schedules and preferences. This approach could ensure that a broader audience can participate, thereby increasing overall reach of the NST CPD session (Bennett & Glasgow, 2009). Stoszkowski and Collins (2022) found that 58% of videos posted by coaches using Flipgrid as part of coach education were uploaded after 8pm. This suggests that, in related contexts, coaches may be able to engage in online learning flexibly, indicating a possible benefit of asynchronous models like the oNST. The oNST, as an asynchronous web-based solution already offers coaches the flexibility to undertake study at a time to suit their needs. However, this flexibility could have been made clearer with regards to the inNST. Considering the main barriers to NST CPD participation identified in this thesis, primarily lack of time, it is recommended to modify the hybrid approach used in this research.

Chapter 3 reveals that most coaches identified in-person sessions (the inNST) as the most preferential session modality, but the second most popular option (with 38% of coaches ranking it second behind the inNST) was synchronous online sessions. A potential solution could involve creating a synchronous online session to complement the oNST, combining the flexibility of online learning with the interactivity of in-person sessions.

5.2.2 Effectiveness

'Effectiveness' relates to the impact that the NST CPD programme has on participants' coaching skills, knowledge, and behaviours (*What Is RE-AIM?*, n.d.). The oNST showed promising results in enhancing self-reported knowledge and confidence among a small group of coaches. This is supported by statistically significant increases in self-reported knowledge and confidence levels, along with positive changes in coaches' perceptions of NSTs and their applications, increasing the likelihood of NST implementation or further educational engagement (Eccles & Wigfield, 2002). Furthermore, an analysis of the responses in the education section of the oNST reveals that coaches answer over 80% of the questions correctly. While the oNST was effective, improvements could be made to improve both its reach and effectiveness by attempting to overcome some of the barriers outlined previously (Chapters 3 and 4). For example, the content and answers related to question 22 could be reviewed as this question was an outliner in terms of correct answers. Further, a limitation of the Wooclap system was the inability to save and return to complete the oNST. This meant that coaches completed the oNST in one sitting, lasting approximately 25 mins. Online learning often results in shorter attention spans compared to traditional in-person environments, with the average attention span ranging from 10 to 15 minutes, depending on engagement and content complexity (Bradbury, 2016). This is due to factors including increased distractions, passive content, and lack of physical interaction. Bunce et al., (2010) found more frequent attention lapses in online settings, emphasising the need for interactive elements and

breaks to maintain focus. Techniques such as quizzes, discussions, and multimedia can help sustain attention (Zepke & Leach, 2010), thus some of which were included as part of the oNST.

Whilst the whole NST CPD session was made up of the oNST and inNST, the oNST could be further sub divided, potentially into five sections – (1) introduction, (2-4) each of the three screens plus review questions, (5) final review questions and summary. Cognitive load theory supports this sectioning of the oNST into smaller chunks as it could enhance attention and retention (Sweller, 1988). Therefore, structuring the oNST with more short, focused segments and interactive activities could better align with learners' natural attention spans and improve learning outcomes (Mayer & Moreno, 2010). It is noted in Chapter 4 that there was no significant difference between the correct answer rates between closed and open questions, supporting the inclusion of both in the oNST. However, research also points to the fact that open-ended questions demand deeper understanding and independent recall, making them more challenging (Freeman et al., 2014). Thus, a further proposal would be to increase the number and frequency of open questions throughout the oNST.

Notwithstanding the effectiveness of the oNST, the hybrid nature of the NST CPD tool faced limitations, as no coaches opted to participate in the in-person component during this pilot. This outcome was unexpected, especially considering that most coaches (72%) prefer in-person CPD over online CPD (Chapter 3). Chapter 2 details research suggesting that coach education programmes should transition from traditional 'knowledge transfer' methods to a collaborative learning approach that encourages the sharing and development of coaching knowledge within specific contexts (Côté, 2006). Guided by this principle, the inNST was developed to facilitate such coach-led discussions about the NST tool, including its adoption, implementation, and maintenance within clubs, and without evidence to the contrary, could still be promoted as a framework of in-person NST CPD, once the reach is improved.

5.2.3 Adoption, Implementation and Maintenance

'Adoption' refers to the proportion and representativeness of organisations and participants willing to initiate the (NST CPD) programme, along with the factors influencing this. 'Implementation' focuses on the fidelity of programme delivery, including consistency, cost, and adaptations. 'Maintenance' evaluates the programme's long-term sustainability at both individual (coach) and organisational (club) levels (*What Is RE-AIM?*, n.d.). In this thesis, adoption, implementation, and maintenance are examined primarily from a theoretical standpoint, as the long-term use of the NST CPD product fell outside the research scope. In the NST CPD pilot study (Chapters 3 and 4), coaches were asked various questions related to these concepts, providing the researchers with insights that informed recommendations for the potential application of NST CPD in the industry. However, these insights were limited due to a lack of participation in the inNST phase, where the research design intended to engage coaches in discussions about the adoption, implementation, and maintenance of both the NST CPD sessions and the regular use of NSTs within a coach's club or own coaching practice. A distinction is made between the barriers and facilitators to undertaking the oNST and inNST (reach) and those barriers and facilitators that would support the adoption, implementation, and maintenance of the NST in practice.

Time constraints were consistently identified as a barrier to participation in the inNST (reach). It is also anticipated that time would pose a significant challenge to the adoption, implementation, and maintenance of the NST session itself. In Chapter 3, coaches were asked about their ideal duration for conducting the NST session with players. The majority chose an optimal timeframe of 6–10 minutes, with durations becoming less popular as the length of time increased. Time constraints were identified as a significant barrier to the implementation and adherence to IPEPs and the FIFA 11+ (Junge et al., 2010; O'Brien & Finch, 2016). As a result, many coaches modified IPEPs, potentially diminishing effectiveness (O'Brien & Finch, 2016). It is possible that these time-related modifications stem from a lack of awareness among coaches, though this was not directly

assessed in this study. Additionally, Chapter 3 found that the second most significant barrier to implementing NSTs in grassroots youth football was the lack of facilities, with 33% of respondents ranking it as the next major obstacle behind lack of knowledge. Chapter 3 highlights the importance of considering equipment and space requirements when selecting an NST screen. For instance, the mSEBT was chosen over the YTB partly because it required less specialised equipment. Although grassroots coaches express significant concern about facilities, particularly the availability and cost of football pitches (as discussed during the interviews in Chapter 3), their perception of this as a barrier to adoption, implementation, and maintenance may stem from a lack of awareness regarding the minimal facility and equipment needs of the NST. This creates a cyclical issue: coaches, possibly due to limited knowledge and understanding of NSTs (reach), might assume that NSTs need to be conducted as frequently as IPEPs, or require significant investment in equipment, when in fact, NSTs used in this study can be administered more sparingly throughout the season - potentially as few as three to four times - and were deliberately chosen as they require very little equipment. As Junge et al., (2010) found that the main reason coaches did not undertake the FIFA 11+ was due to lack of awareness and knowledge of the programme (reach), adoption, implementation, and maintenance of the NST can only be improved if reach is increased.

Coaches highlighted that securing buy-in from both players and parents is crucial for the successful adoption, implementation, and maintenance of NSTs (Chapter 3). They observed that challenges in gaining this support often stemmed from a perceived lack of expertise on the part of the coach. Unsurprisingly, coaches identified increased knowledge as the key factor that could facilitate NST adoption, implementation, and maintenance. It is suggested that by enhancing their understanding of NSTs (their uses and benefits) coaches would be better equipped to convey the value of these programmes and persuade players and parents to 'buy in'. Some coaches also believe that a

collection of case studies on NSTs would strengthen this argument, particularly in the short term (Chapter 4).

5.3 Communities of practice

When coaches encounter new learning opportunities, various individual factors influence whether they adopt, modify, or reject new knowledge (Stodter & Cushion, 2017). A crucial factor is a coach's established dispositions and habitus, which shape their approach to learning. For instance, a coach's learning horizons can limit their ability to recognise and integrate new ideas in informal learning contexts (Leeder et al., 2021). Bourdieu's (1990) view that habitus produces consistent patterns of behaviour across different contexts is challenged by Wenger's (2000) idea of communities of practice (CoP). Wenger views habitus as an evolving aspect of interacting practices, where experiences within CoPs can modify individual dispositions. A CoP is where professional learning communities and social networks play a crucial role in the dissemination and adoption of new educational practices. These networks can facilitate the spread of innovations through social influence (Wenger, 2000). Consistent evidence from both the healthcare and education sectors indicates that the acceptance of new approaches by peers positively influences colleagues' adoption of these new initiatives (Gresczcuk et al., 2018; Penuel et al., 2007). Supporting this view, it was found that coaches believe that the common usage of a NST programme among other clubs and peers would enhance the adoption, implementation, and maintenance of the NST programme (Chapter 4).

In Chapter 3, it was recommended that the inNST be designed through a social constructivist lens to anchor learning in real-world contexts. This approach enables student coaches to draw upon their personal experiences, expertise, values, and abilities, fostering the development of new

insights within a learner-centred framework. This paradigm is consistent with the principles of CoPs. Supporting this notion, focus group participants (Chapter 3) proposed establishing ongoing community support within their coaching networks, leveraging online platforms such as Facebook to facilitate communication and resource sharing.

Establishing a CoP may support adoption, implementation, and maintenance of NST programmes, though this would benefit from further empirical testing. Moreover, it could improve the reach of NSTs through industry-driven word-of-mouth recruitment. As discussed earlier, synchronous online sessions can further increase reach by lowering the time and cost barriers associated with in-person attendance. These synchronous online sessions could also serve as a platform to develop a CoP. However, to avoid superficial discussions that fail to produce meaningful outcomes, these conversations must be structured to maximise the effectiveness of the CoP (Whitaker & Scott, 2019).

It may be beneficial for the CoP sessions to proceed the oNST, allowing participants to gain prerequisite knowledge of the NSTs thus enabling more focused discussions and reflections during the CoP. Alternatively, due to the poor reach for the subset of coaches who are more experienced and qualified than the average oNST participant, the oNST could be integrated into the first CoP meeting, which may help change the dynamic of the participants completing the oNST who may have previously not considered the oNST suitable for themselves. The conversations should centre on challenges related to NST RE-AIM (i.e. how to improve reach, effectiveness etc), strategies to overcome these challenges, and the creation of actionable plans by coaches (Whitaker & Scott, 2019). As suggested in Chapter 2, a designated CoP leader would facilitate these discussions, guiding participants and leveraging the 'physical' presence (albeit, an online one) to maintain engagement and commitment. This broad framework aligns with the first three sections of the Value Creation Framework (Figure 28 - Whitaker & Scott, p. 28, 2019)

The capacity to experiment with and evaluate new tools or solutions in response to perceived barriers in coaching practice ('Applied value') is a cornerstone of CoP (Whitaker & Scott, 2019). Chapter 2 highlighted Flipgrid as an effective online tool for coach reflection, indicating that a synchronous online CoP would have the necessary digital support to succeed. Additionally, the use of Flipgrid (or similar tools) alongside the digital platform used for the oNST aligns with the FA's goal to increase digital engagement in grassroots football (The Football Association, 2021), which could help promote NGB 'buy-in', thereby increasing the reach of NSTs in youth grassroots football. Chapter 2 also identifies that a key facilitator of NST training and its use is the availability of relevant case studies. Documenting reflections from NST CoPs and NST practice can contribute to the development of case study examples that can be shared within the industry, thereby enhancing the perceived value of these practices ('Realised value'). This, in turn, could indirectly support improvements across all aspects of the RE-AIM framework.

One limitation noted in this thesis is the inability to measure the AIM components of the RE-AIM framework due to the absence of longitudinal research. However, CoPs are inherently longitudinal in nature (Whitaker & Scott, 2019). Therefore, the long-term study of an NST-focused CoP would complement the 'moment-in-time' research on the oNST and inNST that is presented in this dissertation ('Reframing value').

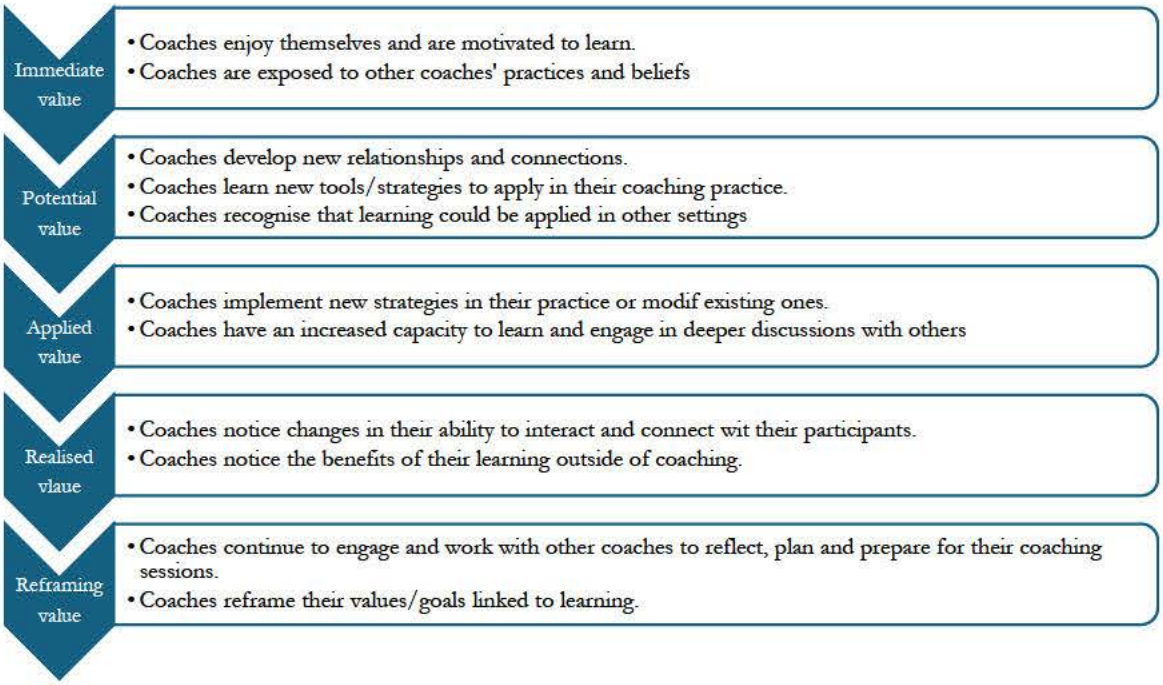


Figure 28. Value Creation Framework found in Whitaker & Scott (p. 28, 2019) from Wenger et al., (2011)

5.4 Positioning within Grassroots Football: Challenges, Barriers, and Implications for Practice

The development and piloting of a novel hybrid NST and accompanying CPD session outlined in this thesis has been explicitly grounded in the realities of grassroots football, particularly within the context of adolescent female participation. Grassroots football, while rich in community value and accessibility, remains an under-resourced and highly variable environment (The FA, 2021). Consequently, any intervention aimed at enhancing coaching practice or player welfare must contend with a range of deeply embedded challenges and systemic barriers.

5.4.1 Structural and systemic barriers

One of the primary challenges in grassroots football is the chronic reliance on a volunteer workforce. As evidenced throughout this thesis, the majority of coaches in grassroots football are part-time, unpaid, and often lack formal pedagogical or sport science training (Stoszkowski & Collins, 2017). The findings from Chapter 3 confirm that most coaches reported little to no prior exposure to movement screening concepts, and many held only entry-level coaching qualifications. This systemic lack of foundational knowledge around athlete health, injury prevention, and physical development contributes to an ongoing skills gap within the sector (De Ste Croix et al., 2020).

Moreover, grassroots environments frequently operate with minimal financial and infrastructural support. Coaches often work with limited access to facilities, equipment, or ongoing professional development (Duncan et al., 2022). These material constraints intersect with practical issues such as time scarcity, as repeatedly cited in both Chapter 3 and oNST feedback data (Chapter 4). The implications for coach education are significant: interventions must be low-cost, flexible, and immediately applicable in order to gain traction.

The reach of existing injury prevention or screening initiatives has been historically poor within grassroots contexts. As noted in both this study and previous research (Donaldson et al., 2018; Junge et al., 2011), awareness of high-profile programmes like FIFA 11+ remains low, even when these tools are well-publicised at the national level. This suggests a persistent breakdown in dissemination and uptake pathways between governing bodies and volunteer coaches, underscoring the need for more targeted, context-sensitive delivery models such as the oNST.

5.4.2 Challenges in the female game

While barriers exist across grassroots football as a whole, they are magnified within the female game. There remains a legacy of underinvestment and marginalisation in women's football at all levels (Williams, 2003). Despite recent growth in participation and visibility, many female teams still lack parity in access to training facilities, coaching expertise, and medical support compared to their male counterparts. This disparity is particularly concerning given the higher injury risk profile in female athletes, especially for ACL injuries (Hewett et al., 2006).

The oNST was developed with this context in mind, offering a practical screening solution that can be implemented with minimal resources. However, its limited reach (as discussed in Chapter 4 and 5) reflects broader structural issues, including gendered disparities in coach education engagement and resource allocation. As such, implementation strategies for future NST CPD products must consciously address the specific barriers encountered in female grassroots settings.

5.4.3 Cultural norms and coach identity

An additional barrier within grassroots football lies in cultural perceptions of coaching roles. Many grassroots coaches, especially those operating at younger age groups, perceive their primary responsibility as fostering enjoyment, inclusion, and basic skill acquisition (Stodter & Cushion, 2017). Health- and performance-oriented practices such as movement screening may be viewed as beyond their remit, overly 'elite', or even intimidating in terms of knowledge requirements. This cultural resistance can be compounded by coach identity. Coaches who do not see themselves as 'experts' or 'scientists' may self-exclude from CPD offerings that appear overly technical or academic (Nelson et al., 2013). The co-production approach used in this thesis sought to mitigate this by involving coaches in the design of the tool and demystifying the process through accessible online learning (the oNST). Early feedback suggests that this may help lower psychological barriers

to participation, although further scaling is required to assess longer-term shifts in perceptions and identity.

5.4.4 Implications for practice

This study presents several practical implications for stakeholders in grassroots football. Firstly, it demonstrates that coach education on injury risk screening is feasible within grassroots environments when delivery is coach-centred, time-efficient, and digitally accessible. The oNST exemplifies this approach and could serve as a model for future initiatives, especially where access to in-person CPD is limited. Secondly, the findings highlight the need for segmentation in CPD marketing and delivery. Coaches differ in experience, confidence, and motivation - ranging from novice volunteers to experienced practitioners - and therefore require varied content and formats. A one-size-fits-all model is unlikely to be effective in such a diverse coaching landscape. Thirdly, the research supports integrating CoPs into coach education. As discussed in Chapter 5, CoPs encourage peer-to-peer learning, critical reflection, and long-term support - factors essential for embedding practices like NST use. In grassroots settings, online CoPs may be the most viable and scalable format, especially when supported by governing bodies and hosted on platforms like Flipgrid or Microsoft Teams. Finally, the thesis underscores the crucial role of national governing bodies (NGBs). The success of grassroots CPD interventions often hinges on the visibility, endorsement, and infrastructural support provided by NGBs. Without such backing, even effective tools risk poor uptake, as seen with the limited adoption of FIFA 11+. The Football Association's recent focus on digital engagement (The FA, 2021) provides an opportunity to align NST education with broader strategies and improve its dissemination across the grassroots game.

5.5 Final conclusions

The research presented in this thesis focused on the development and pilot testing of a novel hybrid NST CPD product designed for grassroots coaches of adolescent female footballers. This initiative was born out of a real-world need to empower volunteer coaches to identify players with abnormal movement patterns, which could increase injury risk. A significant strength of this research lies in the active involvement of these coaches throughout the entire process, from surveys and interviews to co-production focus groups and pilot testing. This collaborative approach helped create a potentially valuable solution, with future research needed to assess its integration into professional coaching practices.

The modified RE-AIM framework served as a guiding structure for evaluating this hybrid NST CPD product, particularly focusing on the dimensions of reach and effectiveness. The findings revealed that while the oNST demonstrated effectiveness in enhancing coaches' knowledge and confidence, its overall reach was limited. Many coaches were initially unaware of NSTs, and the response rates to the oNST were low, suggesting a need for targeted strategies to increase awareness and participation. Segmenting the target audience based on factors such as age, experience, and coaching qualifications could help tailor marketing efforts and improve the programme's reach.

Time constraints were identified as a significant barrier to participation in both the oNST and inNST, as well as a potential challenge for the adoption, implementation, and maintenance of NSTs in practice. Addressing these barriers through increased flexibility in session formats, such as offering synchronous online sessions, could enhance both the reach and effectiveness of the NST CPD product. Moreover, the establishment of CoPs could further support the adoption and sustained use of NSTs by fostering peer-driven learning and reflection. These CoPs could

contribute to developing and sharing case studies within the industry, potentially illustrating the value of NSTs in practice, thereby supporting improvements across all aspects of the RE-AIM framework.

Overall, while the pilot study has laid a strong foundation, further research is needed to explore the long-term feasibility and impact of grassroots NST CPD programmes for coaches of adolescent female footballers, particularly through the lens of CoPs and ongoing industry engagement. Success in this space will depend not only on evidence-based tool design, but also on sustained collaboration with coaches, structural support from governing bodies, and an acute sensitivity to the lived realities of grassroots sport. This would ensure that the initial successes documented in this thesis translate into sustained, meaningful change in grassroots coaching practices.

Chapter 6: Reflective discussion: Embedding neuromuscular screening and athleticism into coach education

6.1 Introduction

This thesis has explored the development and piloting of a novel hybrid NST and accompanying CPD training session that is intended to support grassroots football coaches, particularly those working with adolescent female players. Although initial findings point to the oNST's potential as an accessible and flexible CPD solution, the broader issue of how, and indeed whether, such tools should be implemented in grassroots sport remains unresolved. This chapter offers a critical reflection on these questions. It considers how screening and the broader concept of athleticism can be embedded meaningfully in coach education, discusses the potential benefits and drawbacks of using such tools, and examines their philosophical, practical, and ethical implications. This reflective discussion draws upon the empirical findings of the thesis while positioning them within wider academic and applied discourses around youth sport, long-term athlete development, coach learning, and injury prevention. In doing so, it seeks to clarify the potential role of screening in grassroots football, and identify the conditions required to ensure its ethical and effective application.

6.2 Conceptual foundations: Understanding movement quality and athleticism

Movement quality encompasses an athlete's ability to perform fundamental movement patterns with control, stability, and efficiency. In the context of youth development, movement quality is closely linked to the development of athleticism - a broad construct incorporating agility, balance, coordination, speed, and strength (Wijekulasuriya, et al., 2025). The justification for screening in this context is rooted in the assumption that identifying movement inefficiencies early in a player's development may help reduce injury risk and support long-term physical development (Myer et al., 2011).

Traditionally, the use of movement screening tools such as the Functional Movement Screen (Cook et al., 2006), the Star Excursion Balance Test (Gribble et al., 2012), and the Y-Balance Test (Bulow et al., 2019) has been confined to elite sport and clinical settings. These tools have been used to profile athletes, detect asymmetries or neuromuscular deficits, and guide individualised training or rehabilitation. However, there may be increasing interest in transferring elements of these practices to grassroots settings, informed by research suggesting that early exposure to high-quality movement training may improve physical literacy, prevent injuries, and enhance long-term engagement in sport (Ford et al., 2011; Lloyd et al., 2015).

Embedding such practices into grassroots coaching, however, is not straightforward. Grassroots coaches operate in highly variable environments with limited resources, variable qualifications, and diverse motivations (Stoszkowski & Collins, 2017). Any attempt to integrate screening into this

context must acknowledge these realities and consider whether tools developed in elite sport can, or should, be adapted for more inclusive and accessible settings.

6.3 Reflections on the NST and CPD session: Strengths, opportunities, and limitations

The NST and CPD session developed through this thesis was designed to meet the unique needs of grassroots coaches. By combining an asynchronous online module (oNST) with a planned in-person workshop (inNST), the tool sought to offer both theoretical grounding and practical application, while respecting coaches' time constraints and logistical barriers. The oNST was particularly well received, with participants reporting statistically significant improvements in self-perceived knowledge and confidence.

The tool was also designed to encourage reflective engagement with the principles of movement screening. Through scenario-based questions and immediate feedback mechanisms, coaches were not only introduced to core screening techniques (e.g., mSEBT), but also invited to consider how these practices could be applied in their own settings. This design aligns with constructivist theories of adult learning, which emphasise contextualisation, self-direction, and experiential engagement (Knowles et al., 2005).

However, several limitations were evident. Most notably, there was no uptake of the inNST component, despite survey responses suggesting a preference for in-person CPD. This discrepancy underscores the gap between intention and behaviour in CPD participation, a finding supported

by Stoszkowski and Collins (2022), who argue that time, accessibility, and relevance are often more important than modality. It also highlights a critical consideration for coach educators: digital delivery may be more effective not only due to convenience, but because it allows coaches to learn on their own terms.

Another limitation relates to coaches' pre-existing dispositions. Many grassroots coaches, particularly those without formal training in physical development, may perceive screening as overly technical, or even inappropriate within a participation-focused environment. This concern was echoed in several interview comments from this study and is supported by broader literature on coach identity, which suggests that coaches' prior beliefs and learning histories heavily influence their willingness to engage with new practices (Stodter & Cushion, 2017). Further, there is a risk that tools like the oNST may create a false sense of competence. As noted in Chapter 4, increases in confidence may not always be accompanied by increases in actual competence (Dunning et al., 2003). Without opportunities for practice, feedback, and critical reflection (as planned in the inNST), brief interventions such as the oNST, however well designed, may leave coaches with an inflated sense of expertise. This is particularly risky when it comes to activities that have implications for athlete health and wellbeing.

6.4 Should screening tools be used in grassroots sport?

A central question - whether screening tools should be used in grassroots football - is both timely and complex. On one hand, tools like the oNST and inNST can enhance coaches' understanding of movement, raise awareness of injury risk factors, and support long-term athletic development. On the other, they risk overburdening volunteer coaches, introducing medicalised practices into

recreational environments, and identifying problems that coaches lack the capacity or resources to address.

The broader trend of medicalisation in sports coaching - marked by the growing influence of biomedical knowledge, language, and practices - raises significant concerns. Chief among these is the erosion of professional boundaries between coaches and healthcare professionals. Horan et al. (2023) warn that when coaches, without formal medical training, make decisions related to injury management or return-to-play protocols, athlete welfare may be compromised. These decisions can inadvertently prioritise performance over health. Ekstrand et al. (2019), studying elite football environments, found that clubs with poor communication between medical and coaching teams had higher injury rates and lower player availability. While elite-focused, the findings reinforce the need for clear structures and responsibilities - something often lacking in grassroots settings. In the amateur game, the risks of medicalisation are amplified by the limitations of resources and coach education. Malcolm (2006) argues that introducing medical frameworks into community sport can create tensions between safeguarding ideals and day-to-day realities. Volunteer coaches may feel ill-equipped to interpret screening data, leading to anxiety, confusion, or mismanagement. This shift in framing, from holistic player development to biomedical surveillance, risks conceptualising injury and recovery through a clinical lens, which may conflict with the developmental ethos of grassroots coaching. Medicalisation may also negatively alter the coach-athlete relationship. Jowett and Cockerill (2003) argue that treating athletes as patients risks diminishing the human, relational aspect of coaching. In youth sport especially, where trust, empathy, and enjoyment are vital, this shift can be damaging. Furthermore, medical models often frame disability as deficit, limiting inclusive practice (Townsend et al., 2015). In diverse grassroots settings, this risks excluding athletes who do not conform to normative performance benchmarks.

Nesti (2010) cautions that when youth athletes are constantly viewed as "at risk," it can foster a culture of fear and surveillance. Rather than supporting inclusion and enjoyment, this environment may undermine intrinsic motivation and reduce the psychosocial benefits of participation. There are also ethical concerns: clubs with access to physiotherapy or screening tools may gain competitive advantages, while less resourced clubs fall behind. Green (2008) warns that such disparities can reinforce broader social inequalities, unintentionally stratifying grassroots football along economic lines.

To address these challenges, it is essential to distinguish between screening for clinical diagnosis and screening for coach education. In elite sport, screening supports individualised training plans or referrals. In grassroots football, these functions are neither realistic nor appropriate. However, screening as a formative and reflective tool may still offer considerable value. Used appropriately, it can help coaches observe broad trends in movement, reflect on training design, and improve session planning without the pressure of diagnosis or labelling.

In this sense, the oNST and inNST should not be seen as diagnostic tools, but as frameworks that encourage reflective practice. Their purpose is not to categorise players as "high" or "low" risk, but to help coaches recognise which players may benefit from additional neuromuscular support, and how warm-ups, progressions, or technique cues might be adapted accordingly. This aligns with player-centred coaching models that prioritise learning, adaptability, and physical literacy (Côté et al., 2007).

When implemented with these intentions, screening can support - not replace - core coaching responsibilities. It may empower coaches to build safer, more developmentally appropriate sessions, without medicalising the coaching role. For this to succeed, tools like the oNST must be clearly framed as educational rather than clinical, with support materials that build coach confidence and avoid jargon. In this way, movement screening can remain grounded in the realities of grassroots football, enhancing rather than burdening the volunteer coach.

6.5 Embedding movement and athleticism in coach education

6.5.1 Broadening coaching knowledge

Embedding NST's meaningfully into grassroots football requires a broader conceptualisation of what constitutes essential coaching knowledge. Traditional coach education, particularly at grassroots levels, often prioritises technical and tactical instruction at the expense of physical development and player wellbeing (Partington & Cushion, 2013). While such prioritisation may reflect performance-oriented cultures or time-limited CPD formats, it risks creating a gap in foundational understanding of youth physical development, especially during critical periods of maturation in adolescent athletes. Expanding coaching curricula to include physical literacy, growth and maturation, and fundamental movement competency is vital. Athletic development in youth should not be seen as separate from skill acquisition but as part of a broader, integrated model of long-term athlete development (Lloyd et al., 2015). Without grounding in these principles, coaches may overlook or misunderstand the rationale for NSTs, or, worse, misapply them. Embedding movement-related content helps coaches contextualise physical performance, understand injury risk, and tailor training to developmental readiness.

Importantly, this knowledge does not need to be delivered through abstract lectures. Short, practical modules like the oNST can be used to introduce core concepts in a time-efficient and engaging way. Research indicates that CPD is most effective when situated in real practice, ongoing over time, and grounded in reflection (Armour, 2010). By using accessible language, video examples, and practical demonstrations, the oNST encourages coaches to see movement quality as an integral, not additional, part of their coaching toolkit.

This expansion in coach education is particularly relevant in the female grassroots game. As highlighted earlier in the thesis, female players are often underexposed to structured athletic development opportunities (Jones et al., 2022). Equipping coaches with knowledge in this area may therefore help redress systemic imbalances, offering players more equitable support in their developmental journey.

Furthermore, embedding physical literacy in coach education also aligns with safeguarding and ethical practice. Coaches who understand physical development are better positioned to identify atypical movement patterns, respond appropriately to fatigue or growth-related issues, and foster positive messaging around bodies and movement. In this way, broadening coaching knowledge not only improves implementation of tools like the NST, but also contributes to the holistic development of the athlete.

6.5.2 Differentiated CPD pathways

A key challenge in embedding movement screening within grassroots football lies in addressing the heterogeneity of the coaching population. As this thesis has shown, coaches differ significantly in their knowledge, experience, confidence, and values. A standardised CPD approach is unlikely

to meet the needs of this diverse group. Instead, differentiated and flexible pathways are needed to ensure equitable and effective learning (Stoszkowski & Collins, 2015).

Differentiation in CPD involves tailoring learning experiences to coaches' contexts, goals, and readiness. For example, novice coaches, who may be parent volunteers, may lack confidence in physical development and benefit from scaffolded, highly practical learning with clear applications. In contrast, more experienced coaches may prefer opportunities for critical discussion, peer exchange, or reflective practice. Tiered CPD models, such as the three-tiered NST offer (oNST, inNST, and CPD mentoring – discussed below), exemplify how differentiation can be operationalised within movement-related education.

Online and blended formats can also facilitate differentiation by offering content in modular forms that coaches can engage with at their own pace. As highlighted in this thesis, platforms like Flipgrid or MS Teams allow asynchronous discussion, video sharing, and reflection. This is especially relevant given the voluntary nature of much grassroots coaching, where time is a barrier to sustained learning engagement (Nelson & Cushion, 2006). Another dimension of differentiation involves respecting the multiple identities and values that coaches bring to their roles. Some may identify strongly as 'developers' while others may be more results-oriented. Framing the NST as a tool that supports both injury prevention and performance enhancement can help engage different coaching philosophies and build common ground. Aligning CPD with coaches' existing beliefs is crucial to facilitating meaningful change (Abraham & Collins, 2011).

Ultimately, differentiation is about reducing barriers to engagement and creating conditions where coaches feel competent, supported, and autonomous in their learning. This aligns closely with self-

determination theory (Deci & Ryan, 2000), which holds that learners thrive when their needs for autonomy, competence, and relatedness are met. By offering multiple entry points and formats, differentiated CPD respects the diversity of grassroots coaching and enhances the likelihood that NSTs will be adopted and sustained.

6.5.3 Communities of Practice

The implementation of NSTs cannot rely solely on one-off CPD events. Embedding new practices requires opportunities for ongoing reflection, adaptation, and peer support. CoPs offer a promising vehicle for sustaining coach learning over time. In a CoP, practitioners share common interests, engage in joint activities, and develop a shared repertoire of knowledge and practices. In the context of NST implementation, CoPs provide a platform for coaches to reflect on their screening experiences, discuss challenges, and collaboratively develop solutions. CoPs in sports coaching have been shown to support knowledge construction, critical thinking, and professional identity development (Whitaker & Scott, 2019). Within CoPs, coaches can interrogate their own practice, compare approaches, and gain reassurance from peers navigating similar implementation issues.

Digital tools, such as Flipgrid and video conferencing, make CoPs more accessible than ever, particularly important in a dispersed and time-pressured volunteer coaching landscape. These platforms can host discussion threads on screening protocols, injury issues, and feedback strategies, helping normalise and routinise the use of NSTs within the coaching community. CoPs could also help mitigate the isolation that many grassroots coaches experience. much coaching occurs in solitude, without consistent support or collaboration (Cushion et al., 2010), thus through CoPs, coaches gain access to a community of support, where learning is iterative and embedded

in real-world practice. Importantly, CoPs can serve as a bridge between CPD and mentoring structures. Peer coaches within a CoP can take on informal mentoring roles, sharing expertise or troubleshooting challenges related to screening implementation. This hybrid model of support reflects the reality of grassroots sport which is often responsive and more reliant on shared practice than formalised instruction.

For sustained NST adoption, CoPs should be intentionally designed and facilitated. Having clear goals (e.g., supporting screening fidelity), designated leads, and structured discussion prompts can help maintain momentum. Over time, these groups can become self-sustaining and evolve into regional or club-based learning networks (discussed below). As such, CoPs are not just a support mechanism, they could be a powerful driver of cultural change within grassroots football.

6.5.4 Mentoring and role models

Yet, while CoPs provide a valuable forum for collective reflection, the integration of mentoring and role model initiatives may offer an additional layer of support to enhance implementation and adherence to NSTs within grassroots football. Mentoring enables novice or less experienced coaches to access practical wisdom, encouragement, and feedback from trusted peers - particularly important when integrating practices that may sit outside a coach's traditional expertise, such as NSTs.

Mentoring is especially relevant in environments where formal coach education is limited or undervalued. Structured mentoring and learning contracts can help overcome the limitations of informal or ad hoc learning, enabling coaches to apply knowledge more confidently and effectively in practice (Mallett et al., 2009). This is critical in the context of this thesis, where the oNST was

positively received but the inNST (designed to offer more hands-on support) saw no uptake. Mentoring could help bridge this gap by offering flexible, interpersonal support that respects coaches' time constraints while reinforcing the application of learning.

Coaches often rely on social sources of knowledge more than formal ones. Coaching knowledge is commonly constructed through conversations with peers, experience, and informal mentoring (Martindale & Nash, 2013; Nelson et al., 2006). These informal networks are integral to coach development, particularly in the grassroots game, where formal support may be minimal. However, the impact of such learning can be amplified through the presence of experienced mentors who can model and guide appropriate behaviours around the use of screening tools, safeguarding, and athlete development.

This idea links closely to the concept of role modelling. Research suggests that coaches are more likely to engage with and adopt new practices when they see them modelled by respected practitioners. Leeder et al. (2021) found that coaches valued CPD more when delivered by workshop tutors who possessed elite-level experience, indicating that "symbolic capital" plays a major role in uptake. For grassroots settings, this implies that CPD and new initiatives like the NST will be more readily adopted when introduced or supported by coaches who are seen as credible and relatable.

Role models can also play a motivational role. Søvik et al. (2017) demonstrated that using experienced coaches (rather than researchers) to deliver health-promoting programmes helped improve uptake, confidence, and fidelity. This mirrors Bandura's (1997) notion of vicarious experience where watching similar others succeed increases self-belief and willingness to engage.

Moreover, coaches are not only recipients of role modelling, they are role models themselves. As Jacobs et al. (2015) suggest, grassroots coaches frequently operate as educators, psychologists, and mentors to their players. This places additional importance on ensuring that coaches are confident and competent in the practices they employ.

Practically, mentoring and role modelling could be embedded into the NST framework in several ways. In the inNST, experienced coaches who have completed the oNST could act as peer mentors, observing sessions and offering feedback. The oNST itself could include short videos featuring grassroots coaches demonstrating how they integrate movement screening into their practice, effectively acting as remote role models. Within CoPs, mentors could lead small-group discussions, helping to interpret screening results, share ideas, and maintain momentum.

In time, a formalised mentoring structure could be developed in partnership with County FAs or local coaching networks. This would not only enhance the quality of implementation but could also offer a recognition route for experienced coaches who contribute to the development of others. This aligns with the principle of maintenance embedded throughout this thesis in that mentoring schemes can support long-term adoption of tools like the NST by providing both practical guidance and social reinforcement.

Importantly, mentoring may also help guard against some of the ethical pitfalls discussed earlier. Coaches navigating the boundaries between supportive screening and medicalisation may benefit from experienced guidance on how to interpret results, communicate sensitively, and refer appropriately. In this sense, mentors not only help translate technical content into action, but also promote the reflective, relational coaching practices that underpin athlete-centred development.

6.5.5 Creating a supportive club environment

While coach development is vital for implementing neuromuscular screening tools (NSTs), the broader club environment plays a crucial role in sustaining these practices. In grassroots football—where coaches are often part-time, volunteer-based, and subject to frequent turnover (Stoszkowski & Collins, 2017)—embedding screening as a club-wide initiative, rather than an individual effort, is essential for long-term success.

In this thesis, coach participants were self-selected due to personal interest. However, to ensure screening continues beyond individual enthusiasm, it should be embedded into a club's culture and operational routines. This means integrating NSTs into pre-season planning, aligning them with warm-ups, and formalising expectations through policies or shared values. As Lyle (2002) notes, sustainable coach education must align with organisational systems—something that applies equally in grassroots contexts.

Embedding NSTs at the club level supports organisational learning, where practices and knowledge are distributed across the coaching team rather than isolated in individuals (Cushion et al., 2003). Practical strategies include appointing a physical development lead, running internal CPD events, or using platforms like Microsoft Teams to share outcomes and reflections. This fosters a culture of collective responsibility and continuous improvement, increasing awareness among other stakeholders such as safeguarding officers and parents. Such a whole-club approach mitigates disruption caused by staff turnover. When movement screening becomes "how we do things here," new coaches are more likely to inherit and maintain these practices, supported by

documentation, peer mentoring, and shared expectations. This reflects the idea of 'institutional memory'—a key but often overlooked factor in community sport continuity (Nelson et al., 2013).

Clubs adopting this model are also more likely to experience wider benefits, including lower injury rates, improved physical literacy, and stronger alignment across coaching teams. It ensures players receive consistent support across age groups and coaching transitions, enhancing the developmental environment.

Finally, embedding NSTs at the club level helps address ethical and safeguarding concerns. It distributes responsibility for data handling, follow-up actions, and communication more evenly across the organisation. This not only reinforces duty of care but also clarifies the boundary between medical and coaching roles, improving transparency and referral procedures.

6.5.6 A player-centred screening process

While this thesis has rightly focused on equipping coaches with the tools and knowledge to implement NSTs, there is a parallel need to engage players themselves in the process. In adolescent grassroots football, players are not passive recipients of training, rather they are active participants whose motivation, understanding, and perceived value of interventions can significantly affect both their outcomes and the sustainability of those practices (Light, 2013). When players understand how screening relates to their personal goals (i.e. improving balance to reduce injury risk or enhancing agility to boost performance) they are more likely to value and engage with follow-up activities. Furthermore, involving players in the design of their own corrective exercises programme, perhaps using peer support, could help personalise the intervention and promote long-term habit formation. This increased player ownership also creates a mechanism for

sustainability across clubs. Given that players may change teams more frequently than coaches, they can act as informal knowledge carriers, introducing new coaches to the NST process or asking to continue exercises they find beneficial. This aligns with the concept of 'brokers' in CoPs where individuals carry knowledge between settings and help bridge practice across contexts (Wenger, 1998). Moreover, by involving players in movement screening, clubs can foster a culture of body awareness and self-care, encouraging players to monitor their own development. In adolescent females, who may face particular social and psychological barriers to physical engagement (Slater & Tiggemann, 2011), this can be empowering. When delivered sensitively and with appropriate language, screening can help demystify physical performance and promote a healthy, developmental mindset.

6.6 Ethical considerations and safeguarding

Introducing screening into grassroots football raises several ethical questions. First is the issue of consent. Young players and their parents must be fully informed about the purpose of screening, how the data will be used, and what the limitations are. Clear communication is essential to avoid misunderstandings or unrealistic expectations.

Second, there is the risk of negative labelling. Identifying players as having "poor movement" can have unintended psychological effects, particularly during adolescence, which is a=a period marked by heightened sensitivity to feedback and self-image (Horn, 2004). Coaches must be trained not only in how to interpret screening results, but in how to communicate them constructively.

Third, screening must not be used as a selection tool. In grassroots sport, the primary aim is participation and development. Screening should not become a barrier to entry or a justification for exclusion. Its use must be framed within an ethos of support, not assessment.

Finally, coach education must ensure that screening is not used to replace broader pedagogical reflection. Good coaching is not about data collection but about relationships, observation, and adaptation (Jowett & Cockerill, 2003). Screening can inform this process, but it should not be positioned to replace the professional judgement and holistic awareness that underpin effective coaching.

6.7 Conclusion

The integration of neuromuscular screening tools into grassroots coach education presents both promise and peril. When used as a reflective, educational device, such tools can enrich coaches' understanding of movement quality, support the development of athleticism, and contribute to safer, more effective training environments. However, these benefits will only be realised if screening is contextualised within a broader pedagogical approach—one that respects the realities of grassroots sport, prioritises athlete welfare, and supports coaches in their ongoing professional journey.

Ultimately, the question is not simply whether NSTs should be used, but how, when, and why. This thesis attempts to offer an initial answer: to use them cautiously, ethically, and as part of a coach-centred, education-focused strategy for enhancing youth sport.

6.8 Implementation Roadmap for the NST and CPD Programme

Drawing on the discussions within this thesis, in order to implement the NST and accompanying CPD session with the female grassroots game, the following roadmap is proposed;

1. **Foundation: Clarify of purpose and framing**

- **Objective**: Position the NST as a reflective educational tool rather than a diagnostic or medical intervention.
- **Rationale**: Coaches may resist tools perceived as clinical or elite-focused (Stodter & Cushion, 2017).
- **Action**:
    - Develop clear messaging: the NST supports awareness of movement patterns, not injury diagnosis.
    - Emphasise coach autonomy, observation, and adaptation (Jowett & Cockerill, 2003).

2. **Increase Awareness and Reach**

- **Objective**: Improve coach knowledge and participation in the oNST and inNST.
- **Rationale**: Your data show low awareness of NSTs and low initial engagement.
- **Action**:

- **Segmented marketing**: Use coaching demographics to tailor outreach (Kreuter et al., 2003).
- **Targeted campaigns**: Partner with County FAs and girls' football leagues; include female-specific messaging.
- **Leverage NGB support**: As with FIFA 11+ (Junge et al., 2011), NGB endorsement can significantly boost reach.

3. Flexible, yet structured CPD delivery

- **Objective**: Accommodate time-poor, volunteer coaches.
- **Rationale**: Coaches preferred in-person sessions, but actual uptake favoured asynchronous formats.
- **Action**:
  - Offer three progressive tiers:
    - **Tier 1**: oNST (asynchronous) – foundational concepts.
    - **Tier 2**: Live online workshops (synchronous) – applied discussion.
    - **Tier 3**: inNST (optional in-person) – practical, peer-led CoP sessions.
  - Apply cognitive load theory (Sweller, 1988) to segment online content into short modules (approximately five).
  - Reinforce learning through open-ended questions and embedded quizzes (Freeman et al., 2014).

4. **Support implementation through mentoring and role modelling**

- **Objective:** Reinforce adoption of the NST through social learning and peer credibility.
- **Rationale:** Coaches benefit from practical, relational support and are influenced by respected peers (Martindale & Nash, 2013).
- **Actions:**
    - Recruit experienced grassroots coaches to serve as mentors within the CPD framework.
    - Embed short video case studies in the oNST featuring relatable coaches modelling NST use.
    - Assign mentors to facilitate small-group discussions or observe practice sessions.
    - Create recognition pathways (e.g., CPD credits, peer nominations) for active mentors.
    - Align mentoring structures with County FA or club development pathways for sustainability.

5. **Foster CoPs**

- **Objective**: Support long-term learning, adoption, and cultural change.
- **Rationale**: Peer support and social learning are key to embedding new practices (Wenger, 2000).
- **Action**:
    - Establish online CoPs (e.g., via Flipgrid, MS Teams etc).
    - Schedule monthly discussion sessions focused on real challenges.

- Assign a CoP facilitator (coach educator or experienced peer) to guide dialogue (Whitaker & Scott, 2019).
- CoPs can also serve as spaces for case study generation to feed back into the oNST.

6. Embed within coach education pathways

- **Objective**: Integrate NSTs into existing CPD and formal qualifications.
- **Rationale**: Current coach education underemphasises physical development (Duncan et al., 2022).
- **Action**:
  - Collaborate with the FA to embed oNST content into UEFA C and B licences.
  - Develop a modular physical development CPD offer that aligns with the FA Digital Strategy (The FA, 2021).
  - Include clear signposting for coaches (e.g., when to refer to physios or strength coaches).

7. Engage Players as Active Participants

- **Objective:** Promote sustainability and motivation by empowering players to understand and contribute to the NST process.
- **Rationale:** Adolescent athletes' engagement is enhanced when they understand and own their development (Light, 2013).
- **Actions:**

- Offer player-friendly explanations and infographics to communicate the purpose of screening.
- Involve players in choosing or modifying corrective exercises to enhance personal relevance.
- Create tools for players to self-monitor progress or track movement goals (e.g., journals, videos).
- Encourage peer support during warm-ups or injury prevention routines.
- Leverage player knowledge to carry NST practices between teams, acting as cultural "brokers" (Wenger, 1998).

8. Create a Supportive Club Environment

- **Objective**: Embed NST practices within club systems and culture to promote consistency and resilience.
- **Rationale**: Club-wide integration reduces reliance on individual coaches and builds continuity over time (Lyle, 2002).
- **Actions**:
  - Integrate screening into seasonal planning (e.g., pre-season and mid-season reviews).
  - Appoint a physical development lead or NST champion at club level.
  - Host internal CPD events and record implementation milestones using digital tools.
  - Encourage clubs to create onboarding packages that include NST orientation for new coaches.

- Foster "institutional memory" by documenting processes and routines (Nelson et al., 2013).

9. Address ethical and cultural barriers

- **Objective**: Avoid unintended harm from screening.
- **Rationale**: Risks include medicalisation, negative labelling, and exclusion.
- **Action**:
  - Develop coach guidance on how to communicate screening results sensitively (Horn, 2004).
  - Reinforce that movement quality is part of holistic development, not a selection criterion.
  - Embed consent and data protection protocols into NST implementation.

10. Monitor and evaluate implementation

- **Objective**: Generate longitudinal data on adoption, fidelity, and impact.
- **Rationale**: Your current research focused mainly on reach and effectiveness.
- **Action**:
  - Use the full RE-AIM framework (Glasgow et al., 1999) to evaluate long-term use.
  - Track CPD engagement, player outcomes, and coach reflections via integrated feedback tools (e.g., surveys, Flipgrid).

- Encourage CoPs to co-produce "local logic models" for how NSTs fit into their club environment.

11. Further tailor for the female game

- **Objective**: Account for structural inequities and injury risks in female football.
- **Rationale**: Female athletes face higher ACL injury risk (Hewett et al., 2006) and reduced access to resources (Williams, 2003).
- **Action**:
    - Prioritise female-only CPD spaces to increase inclusivity and relevance.
    - Provide case studies and resources specific to female players.
    - Collaborate with women's football networks and organisations (e.g., Women in Football).

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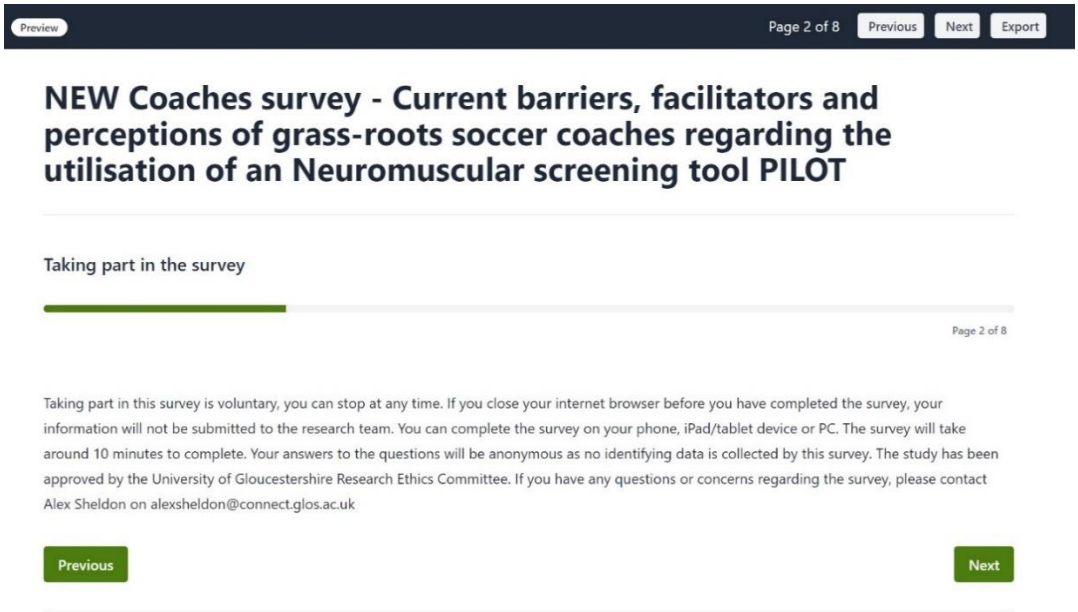
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Chapter 8: Appendices

8.1 Appendix 1 – All-coach survey regarding NSTs





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NEW Coaches survey - Current barriers, facilitators and perceptions of grass-roots soccer coaches regarding the utilisation of an Neuromuscular screening tool PILOT

Consent

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Before deciding whether or not to take part in this study, it is important that you agree with the following statements:

1. I understand why this survey is being conducted.

2. I understand I am able to withdraw from the study before submitting my final answers by closing my internet browser.

3. I understand all data will be completely anonymous.

4. I have read and understood the University of Gloucestershire Research Ethics Handbook of Principles and Procedures. (A copy of the Research Participants Privacy Notice can be viewed in full here) . *

- ○ I consent and agree with how my data will be managed
- ○ I do NOT consent or agree with how my data will be managed

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NEW Coaches survey - Current barriers, facilitators and perceptions of grass-roots soccer coaches regarding the utilisation of an Neuromuscular screening tool PILOT

Demographic information

Question 1 - What is your age? *

Question 2 - What is your sex? *

- [ ] Male
- [ ] Female

Question 3 - What is your highest current FA coaching award? *

- ◯ EE Playmaker
- ◯ Introduction to Coaching Football
- ◯ UEFA C Licence
- ◯ UEFA B Licence
- ◯ UEFA A Licence
- ◯ Advanced Youth Award
- ◯ Other

If you selected Other, please specify:

Question 4 - In total, how long have you coached youth football? *

- [ ] 0-2 years
- [ ] 3-5 years
- [ ] 6-8 years
- [ ] 9-10 years
- [ ] Over 10 years

Question 5 - What age group do you currently coach? *

- ◯ U7-U9
- ◯ U10-U12
- ◯ U13-U16
- ◯ 17+ years
- ◯ Other

If you selected Other, please specify:

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NEW Coaches survey - Current barriers, facilitators and perceptions of grass-roots soccer coaches regarding the utilisation of an Neuromuscular screening tool PILOT

Your history with neuromuscular screening tools

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Question 6 - Prior to this questionnaire, have you ever heard of an neuromuscular screening tool or movement screen? *

- ◯ Yes
- ◯ No

If you have answered "yes" to question 7, which neuromuscular screening tool(s) have you heard of?

- ☐ AIMS-4
- ☐ Athletic Ability Assessment
- ☐ Functional Movement Screen (FMS)
- ☐ Landing Error Scoring System (LESS)
- ☐ Modified-4 movement screen
- ☐ Resistance Training Skills Battery
- ☐ Single leg countermovement jump (SLCMJ)
- ☐ Single leg hop for distance (SLHD)
- ☐ Star Balance
- ☐ The Drop Jump Screening Test (DJST)
- ☐ Tuck Jump Assessment
- ☐ Y-Balance
- ☐ Other

Have you ever used an neuromuscular screening tool in your coaching practice?

- ◯ Very Frequently
- ◯ Occasionally
- ◯ Not sure
- ◯ Rarely
- ◯ Never

Question 7 - Do other coaches at your club use a neuromuscular screening tool? *

- ☐ Very Frequently
- ☐ Occasionally
- ☐ Not sure
- ☐ Rarely
- ☐ Never

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NEW Coaches survey - Current barriers, facilitators and perceptions of grass-roots soccer coaches regarding the utilisation of an Neuromuscular screening tool PILOT

Question 8 - Perceptions of neuromuscular screening tools

Please select the statement which best reflects how well you agree/disagree with this statement: I believe that, if possible, completing a neuromuscular screening tool with my players would be beneficial. *

- ◯ Strongly agree
- ◯ Agree
- ◯ Not sure
- ◯ Disagree
- ◯ Strongly disagree

Question 9 - Please select the statement which best reflects how well you agree/disagree with this statement: Completing a neuromuscular screening tool would be a waste of time/there are more important things we need to do. *

- ◯ Strongly agree
- ◯ Agree
- ◯ Not sure
- ◯ Disagree
- ◯ Strongly disagree

Question 10 - If you were going to conduct a neuromuscular screening tool with your players, how long would you dedicate to the screen? *

- ◯ Less than 5 mins
- ◯ 6 - 10 mins
- ◯ 11 - 20 mins
- ◯ 21 - 30 mins
- ◯ Longer than 30 mins

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NEW Coaches survey - Current barriers, facilitators and perceptions of grass-roots soccer coaches regarding the utilisation of an Neuromuscular screening tool PILOT

Question 11 - Facilitators, benefits and barriers of using a neuromuscular screening tool

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What do you think are the biggest BENEFITS of using a neuromuscular screening tool with your players? Please rank 1 – 5 with 1 being the biggest benefit. *

	1	2	3	4	5
Fitness testing	☐	☐	☐	☐	☐
Help reduce injury/injury screening	☐	☐	☐	☐	☐
Help identify those who are not moving correctly	☐	☐	☐	☐	☐
Improve performance	☐	☐	☐	☐	☐
Help with exercise prescription	☐	☐	☐	☐	☐

Question 12 - What do you think are the biggest BARRIERS of using a neuromuscular screening tool with your players? Please rank 1 – 7 with 1 being the biggest barrier. *

	1	2	3	4	5	6	7
Lack of knowledge/education about NSTs	☐	☐	☐	☐	☐	☐	☐
Lack of facilities	☐	☐	☐	☐	☐	☐	☐
Lack of time	☐	☐	☐	☐	☐	☐	☐
Lack of confidence I could perform it correctly	☐	☐	☐	☐	☐	☐	☐
I don't think the players would want to do it	☐	☐	☐	☐	☐	☐	☐
Lack of buy-in from the club as a whole	☐	☐	☐	☐	☐	☐	☐
I don't think they would add to my coaching practice	☐	☐	☐	☐	☐	☐	☐

Question 13 - What FACILITATORS would help you implement regular neuromuscular screening tool usage in your coaching practice. Please rank 1 – 6 with one being the biggest facilitator. *

	1	2	3	4	5	6
Buy-in/support from the club	☐	☐	☐	☐	☐	☐
Support and education from the FA	☐	☐	☐	☐	☐	☐
Extended training time	☐	☐	☐	☐	☐	☐
A reduction in tactical/game play in order to complete the NST	☐	☐	☐	☐	☐	☐
Better facilities (equipment)	☐	☐	☐	☐	☐	☐
Better facilities (space)	☐	☐	☐	☐	☐	☐

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NEW Coaches survey - Current barriers, facilitators and perceptions of grass-roots soccer coaches regarding the utilisation of an Neuromuscular screening tool PILOT

Confidence of using neuromuscular screening tools

Question 14 - How confident would you be completing a neuromuscular screening tool with your players correctly after you had instruction? *

- ◯ Very confident
- ◯ Confident
- ◯ Not sure
- ◯ Unconfident
- ◯ Very unconfident

Question 15 - What form of instruction would increase your confidence in using a neuromuscular screening tool with your players? Please rank 1 - 4, where 1 is the most important?

	1	2	3	4
Face-to face-workshop (when safe and appropriate)	☐	☐	☐	☐
Live online workshop (via Team, Skype, Zoom or similar)	☐	☐	☐	☐
Online course that you work through at your own pace	☐	☐	☐	☐
User guide/manual that you can take onto the training pitch with you	☐	☐	☐	☐

Question 16 - If there are any other facilitators that would help you implement a neuromuscular screening tool in your practice, please explain these below.

Question 17 - If you have any more comments you feel will be useful, please state below.

Previous Submit



NEW Coaches survey - Current barriers, facilitators and perceptions of grass-roots soccer coaches regarding the utilisation of an Neuromuscular screening tool PILOT

Survey complete

Thank you for taking the time to complete the survey. You may not close this window.

8.2 Appendix 2 - Ethical approval for survey – (ethics approval reference number NSSS.SPRT.05032402)

Please ensure you have read the University of Gloucestershire *Research Ethics Handbook of Principles and Procedures* before completing this form

Please make sure you have completed the Ethics Self-Assessment Checklist prior to filling out this form. This will give you an indication on the types of research designs that require scrutiny from either the School Research Ethics Panel (SREP) or the Research Ethics Committee (REC). On occasion, some research proposals will also need the scrutiny of an external research ethics committee. Please ensure you have discussed this with your module tutor/supervisor/co-researchers.

Contact Details of Lead Researcher	
Name:	Alex Sheldon
Student or staff number:	[redacted]
Please state in which capacity this application is being made (as this affects the gatekeeper process)	Postgraduate Researcher
University e-mail address:	

Contact Details of research supervisor(s) OR module tutor OR co-researcher(s)			
Name:	Prof. Mark De Ste Croix	Name:	Dr Jonathan Hughes
University e-mail Address:		University e-mail Address:	
Name:	Dr Nicola Theis		
University e-mail Address:			

About the Project			
Project Title:	Lower-limb neuromuscular screening tools within female grass-roots youth soccer: Assessing the knowledge, understanding and perceptions of grass-roots soccer coaches.		
Start Date:	Sep 2021	Completion Date:	May 2022

Project Research Questions (include as many as applicable)	
1.	What are the potential barriers and facilitators regarding the implementation of a neuromuscular screening tool for use by grass-roots soccer coaches?

2.	What is the current knowledge, perceptions and confidence levels of grass-roots soccer coaches regarding the utilisation of a neuromuscular screening tool?

Description of the project	
Include answers to the following questions (unless non-applicable):	
1. *Why is the project being carried out?*	The project is investigating if Neuromuscular Screening Tools (NSTs) are currently used by coaches within grass-roots female soccer. If NSTs are not currently in widespread use, the project will aim to find out why not. These questions will allow researchers to tailor future NST developments to meet the needs of the industry and end-suer, thereby allowing for greater implementation and use.
2. *How has it been designed to answer the research questions?*	Data to answer both research questions will be gathered via an online survey. The questions have been developed and modified from previous validated surveys (O'Brien and Finch (2014); Donaldson et al., (2018); De Ste Croix (2020)). The Reach Efficacy Adoption Implementation Maintenance (RE-AIM) framework (Glasgow, Vogt & Boles, 1999) is a well utilised model to evaluate the impact of public health and sports injury interventions (O'Brien & Finch, 2014). Using the RE-AIM framework as a guide, the survey (included with this ethics form) will specifically ask questions to a grass-roots coach around the four main areas contained within the research questions, specifically; • potential barriers to using a NST in their industry • the facilitators for using a NST in their industry • the confidence of the coach in using a NTS • the perceptions that the coach has regarding NSTs.
3. *Who are your participants?*	All participants in this study will be qualified coaches who are registered to coach at a grass roots level and who currently hold a FA Level 1 or Level 2 football coaching qualification. There will be no minimum duration of coaching experience required over and above their qualification. Although FA coaching awards are open to those aged >16, only coaches aged >18 years old will be used in this study.
4. *How will they be recruited?*	Information will be sent out electronically to coaches via their associated soccer club, details being obtained via the Football Association's website (http://www.thefa.com/get-involved/player#fa-find-football) as well as emailed directly to known coaches who meet the inclusion criteria for the study. Furthermore, the survey will also be distributed via social media (namely Twitter) for a period of 3 months. Snowball sampling will be used to locate further participants for the study.
5. *How will data be collected?*	A pilot study will be conducted to ensure comprehension and usability of the survey. This will be completed via a mixture of a Word document that is disseminated to selected participants or via Online Surveys. The

	Word document will allow more precise and constrictive feedback to be obtained from the pilot study whereas pilot testing via Online Surveys will test the working model of the survey and data collect mechanisms. The pilot testing will inform the final draft of the survey. Major alternations to the survey will be submitted wo the ethics panels for their records. Data will be collected via the completion of an online survey. The survey will be developed/hosted using Online Surveys (via the University of Gloucestershire). As per Donaldson et al., (2018), the survey will be developed using the RE-AIM framework outlined by Glasgow et al., (1999). Questions will vary between multiple choice, Likert scale and open questions. The Likert scales will use one to five points and will be fully labelled as these scales have been shown to be more reliable compared to partially labelled scales (Wade, 2006; Krosnick and Presser, 2010). Open questions will be analysed using thematic analysis and questions will be coded and grouped together dependent on theme identified.
6. *Where will data collection take place?*	As an online survey (onlinsurveys.ac.uk), participants are able to complete the form in any location they wish. A copy of the survey and other preliminaries are included with this ethics form which can be viewed here. https://glos.onlinesurveys.ac.uk/new-coaches-survey-current-barriers-facilitators-and-pe
7. *How will data be analysed?*	Data from the survey will be exported into Microsoft Excel. Any missing data will be excluded from the study and not reported on a question-by-questions basis. A response rate will be calculated per question. Likert Scale questions will be coded 1-5 respectively, and descriptive statistics calculated based on the above, including measures of central tendency (mean, median and mode). Questions will be determined, allowing data to be analysed based on; • Current level of coaching qualification • Years of coaching experience ("coaching age") • Sex • Age group(s) coached Any open questions on the survey will be thematically analysed following the 6-step recursive process outlined by Braun and Clarke (2006), roughly outlined as; 1. Data transcription 2. Coding of transcripts 3. Collating codes into potential themes 4. Reviewing themes

	5. Ongoing reviewing of themes 6. Extracting data for results. 7. Likert data grouped into categorical groups ("agree or disagree") will be analysed using Chi Square
8. *Provide a sample size calculation (for quantitative data)*	According to the FA, there are 397,523 Level 1 and 2 coaches collectively in England. Based on a Margin of Error of 10%, 100 completed survey are required. Due to an expected response rate estimated = 24-36% (Mawson et al., 2018; Donaldson et al., 2018), a total of at least 417 participants will be invited to complete the survey.
9. *Has the project any external funding?*	No
10. *Is your research under contract to another organisation? If so, to whom? (please forward the contract to the insurance department)*	No
11. *Brief description of the project (using no more than 500 words – there is no need to reference academic sources).*	Neuromuscular screening tools (NST) used by technical coaches within female grass-roots youth soccer would allow coaches to highlight players who demonstrate neuromuscular dysfunction. The implications for long-term neuromuscular dysfunction include; (a) reduced performance due to poor movement competency, (b) increased susceptibility to injury, resulting in reduction/cessation of sport and physical activity that may potentially lead to chronic health and wellbeing complications. Whilst there has been significant research on the development of NSTs used for assessing neuromuscular dysfunctions (Onate et al., 2012) their successful implementation in industry is uncertain due to a variety of obstacles, including; time constraints, lack of knowledge, equipment needs, funding and perceived lack of need (Myer et al., 2010; Chimera & Warren, 2016). There is a dearth of literature regarding the successful implementation of NSTs within grass-roots level sport as well as a disparity between research focusing on female youth soccer players when compared to their male counterparts. This research aims to gain an understanding of the factors influencing any future development and successful implementation of a NST for use by grass-roots coaches in female grass-roots youth soccer. Once an understanding of these factors has been researched, future NSTs could be developed to account for these factors, allowing for a development of a NST that is more successfully implemented into industry.

Does this proposal contain any REC/SREP mandatory criteria or elements from the Ethics Self-Assessment Checklist?	
No	
If yes, please indicate which	
1) research which involves biomedical or clinical intervention (with the exception of those approved under standard protocols, e.g. those contained in the UoG laboratory handbook)	☐
2) deceptive research	☐
3) covert research or where the data are not recorded in a manner that protects the anonymity of subjects or participants	☐
4) where the research topic is one dealing with sensitive aspects of the subject's or participant's behaviour, or where proposals for research involve vulnerable populations	☐
5) research where participants are under 18	☐
6) research involving work outside the UK	☐
7) research involving assent-based participation	☐
8) research requiring external institutional approval (e.g. NHS, looked after children, young offenders, military personnel)	☐
9) research which involves staff using students as research participants	☐

About the proposed project		
If you answer yes to any of the following questions, please give further details as required.		
1) Have actions been taken to ensure compliance with the Data Protection Legislation?	Actions taken:	This study will abide by the Data Protection Act 2018. All participants will be provided with the data privacy notice, as follows; 'I have read and understood the University of Gloucestershire Research Ethics Handbook of Principles and Procedures.' **Data protection principles** **Ensure information is:** • used fairly, lawfully and transparently

		• used for specified, explicit purposes • used in a way that is adequate, relevant and limited to only what is necessary • accurate and, where necessary, kept up to date • kept for no longer than is necessary • handled in a way that ensures appropriate security, including protection against unlawful or unauthorised processing, access, loss, destruction or damage Data will be kept on a password protected computer and will only be shared with my supervisors on a need to know basis. The data will be kept on a password protected hard drive which will be encrypted with several passwords in accordance with the Data Protection Act (2018) and stored in a locked office. All organisations and individuals will be kept anonymous throughout the project. However, participants will be requested to provide consent to be contacted in the surveys questions. A consent form will embedded into the survey prior to the subjects starting
2) Is partnership /collaboration with another institution involved?	Name of institution:	NA

3)	Has another Ethics Committee approved the project?	Ethics Committee & date of approval:	NA
4)	Have any training needs been identified as necessary for the researcher(s) to complete prior to undertaking the research?	Brief details:	The researcher has undertaken the 1. Reviewing Literature and Critical Reflection and 2. Research design, analysis and integrity in Sport and Exercise modules to further understand ethical and philosophical approaches to various types of research at doctoral level
5)	Have relevant professional guidelines been consulted?	Source of guidelines:	University of Gloucestershire Research Ethics: A handbook of Principles and procedures.
6)	Has another form of 'risk assessment' been undertaken (in addition to this form)?	Brief details (and, if appropriate, please append documents):	NA

Clinical trials insurance: Does the research involve:		
Important: If your research involves any of the following categories, you must refer your application to the University insurance office in order that the relevant liability insurance can be arranged. Under no circumstances can your project commence until you receive confirmation that liability insurance is in place. Contact details for the insurance office: insurance@glos.ac.uk.		
Does the research involve:	**Answer yes or no:**	**Brief details:**
a) investigating or participating in methods of contraception?	No	NA
b) assisting with or altering the process of conception?	No	NA
c) the use of drugs?	No	NA
d) the use of surgery (other than biopsy)?	No	NA
e) genetic engineering?	No	NA
f) subjects under 5 years of age?	No	NA
g) subjects known to be pregnant?	No	NA

h)	pharmaceutical product/appliance designed or manufactured by the institution?	No	NA
i)	work outside of the United Kingdom?	No	NA

Voluntary Informed Consent		
a)	Please indicate what form of consent will be used in this investigation	Written
	If not written, please explain	
b)	How and by whom will the voluntary informed consent from participants be undertaken? *Please indicate in particular if participants/ respondents/ subjects are children or young people, or are members of other 'vulnerable populations'.*	

Consent will be gained by all participants after reading the following statements:

"Before deciding whether or not to take part in this study, it is important that you agree with the following statements:

- I have read and understood the information provided
- I understand I am able to withdraw from the study before submitting my final answers by closing my browser
- I understand all data will be completely anonymous"

If they do not wish to consent at this point they can close their browser or click "I do not agree to take part in this study" and be redirected to a page which says "thank you for your interest in the study".

(Letters to participants and/or any information sheets / questionnaires / interview questions, etc. must be included as appendices when submitting this form.)

Risk of harm			
Please indicate any possible <u>risks</u> to the **researchers, participants, other persons**			
Tick all that apply	RESEARCHERS	PARTICIPANTS	OTHER PERSONS
ENVIRONMENTAL			
Undue environmental damage	☐	☐	☐
LEGAL			
Contravention of legislation on any of: gender, race, human rights, data protection, obscenity, environment	☐	☐	☐

Defamation	☐	☐	☐
PHYSICAL			
Bodily Contact	☐	☐	☐
Lone working	☐	☐	☐
Physical danger/violence (or threat of either)	☐	☐	☐
Research outside of the UK	☐	☐	☐
PHYSIOLOGICAL			
Ingestion of foods, fluids or drugs	☐	☐	☐
Undue physical stress or exertion	☐	☐	☐
Sampling of human tissue, body fluids including venepuncture	☐	☐	☐
PSYCHOLOGICAL			
Psychological intrusion from questionnaires, interview schedules, observation techniques	☒	☒	☐
SOCIAL, CULTURAL & PROFESSIONAL			
Contravention of social/cultural boundaries	☐	☐	☐
Nudity, loss of dignity	☐	☐	☐
Compromising professional boundaries with participants, students, colleagues	☐	☐	☐
REPUTATIONAL			
Research that unduly and adversely affects the reputation of the institutions involved	☐	☐	☐
Other risks identified, but not listed above:			

If you have ticked any of the previous remarks, please describe the actions that will be taken to minimise the risk.

Psychological intrusion from surveys, interview schedules, observation techniques – There may be some intrusion from the survey and the follow up interviews. However, this is deemed not to have a negative psychological effect on the individuals involved, it should however encourage further thought as to how neuromuscular screening could help identify those with dysfunctional movement and subsequently reduce injury and improve performance.

Respondents are free to stop completing the survey at any point if they feel the questions are psychologically intrusive and their responses will not be submitted. They are also free to skip any question they feel they do not want to answer or are not appropriate

Anonymity / Confidentiality
Please indicate measures that will be taken to protect and maintain the anonymity and/or confidentiality of participants. To make sure anonymity is maintained any information that could lead to participant identification will be removed from the study, this including: names, job titles, age and gender. In addition to ensure confidentiality, data will be distributed on a need to know basis between the researcher and assigned research supervisors and kept on a personal password secured. All data will be destroyed after 7 years and kept anonymous, thus coinciding with the advice and regulations as outlined in the Data Protection Act of 2018.
How are you anonymising your data? Participants will be coded to numbers. The only parties who may have access to non-coded data will be the researchers.

Data storage	
What secure storage do you propose to hold your data in?	Data will be downloaded from the Google form into an external hard drive. It will then be analysed in Microsoft Excel, the file of which will be password protected.
What secure premises will the data be stored in? (*e.g., locked lab or office*)	The external hard drive will be kept in the home of the researcher and will not be transported outside of these premises in raw data form.
What are you going to do with your data once the project is complete?	All raw data will be securely kept for a period of 5 years after completion of the research. After that period, all data will be securely deleted/disposed of.
How are you ensuring compliance with relevant data protection legislation?	The project will be run in accordance with General Data Protection Regulation (GDPR) regulations (May 2018)
(Please attach the Privacy notice / PIS as an appendix)	

	Name	Date
Signature of researcher(s)	[redacted]	05/03/2021
	Alex Sheldon	
Signature of supervisor(s) (if appropriate)	Prof Mark De Ste Croix	01/03/2021
	Dr Jonathan Hughes	01/03/2021
	Dr Nicola Theis	01/03/2021

NB: forms not fully completed and signed by researcher/s and supervisor/s (where appropriate) will be returned without consideration for approval.

8.3 Appendix 3 - Interview / Co-production informed consent form / participant information sheet

Study Title: Lower-limb neuromuscular screening tools within female grass-roots youth soccer: Assessing the knowledge , understanding and perceptions of youth grassroots football coaches.

Dear potential participant

You are being invited to take part in a research study that is seeking to investigate the knowledge, understanding and perceptions that youth grassroots coaches of female players have regarding the use of lower-limb neuromuscular screening tools within your sport. Please take time to read the following information carefully before continuing.

What is the Purpose of the study?

The purpose of this study is to research what grassroots coaches in female football think about the use of neuromuscular screening tools, and what understanding they have about their use. The study will seek to gain collective responses from yourself and peers.

What is a neuromuscular screening tool (NST)?

A neuromuscular screening tool is an assessment of movement against a set criterion. This movement will allow assessors to pinpoint if the participant is performing movement in a dysfunctional manner.

Why have I been invited to participate?

You will have probably already completed the proceeding survey which looked to gain a broad overview of coaches' knowledge (etc) on neuromuscular screening tools. This interview will allow more specific and in-depth discussion about how neuromuscular screening tools would work in the female youth grassroots game. If you have not already completed the anonymous survey, you will be required to do this prior to the interview taking place. It will take no more than 5 minutes, is completely anonymous and available online here – https://glos.onlinesurveys.ac.uk/new-coaches-survey-current-barriers-facilitators-and-pe-2

The study forms part of a Professional Doctorate research project at the University of Gloucestershire. By taking part, you consent to your anonymised responses being stored and used for research purposes in line with GDPR legislation.

Do I have to take part?

No. You have the right not to take part in the interview. Furthermore, you have the right to withdraw your participation from this study prior to submission/evaluation of data. Please inform the lead researcher (contact details are included in this Participation Information sheet) if you wish to do so.

What are the possible benefits of taking part?

The data gathered from these interviews will allow the researcher to have a greater awareness about the knowledge, understanding and perceptions that grassroots coaches have regarding the use of lower-limb neuromuscular screening tools with your sport. This information could be used to enhance future development of neuromuscular screening tools, making them more user-friendly and specifically designed for grassroots coaches, especially for use with female players.

How will you collect the data and what happens to the information/results collected in the project?

The interview will be hosted remotely using Microsoft Teams or will be conducted face-to-face if possible. If being interviewed remotely, the platform will record the interview, and you will get a notification when the recording starts. You are welcome to turn off your camera at this point if you wish. Additionally, a second device (smartphone) will record the audio from the interview as a backup. This backup audio recording will be deleted if the MS Teams recording was successful. The recordings are there to enable more accurate interview transcription and data analysis. All interview results will be anonymised during the transcription process. The anonymised results will form part of a Professional Doctorate thesis. Additionally, the anonymised data may form part of publications written for professional or academic literature.

What happens if I do not want to take part in the project?

Participation is completely voluntary, and no details will be recorded for monitoring purposes. You are free to withdraw at any time or decline from any further participation. If you no longer wish to participate or have any questions, please contact [redacted]

What happens if I do want to take part?

By completing this form and emailing it back to [redacted] you confirm that you have read and understood the information sheet above and consent to taking part in the research unless otherwise expressed.

What happens if I want to withdraw after I have already given consent?

You can withdraw at any point during the interview. If you withdraw after 6-weeks, please be aware the anonymised responses will be included in the study as the data would already be included in the analysis.

Ethical Approval and funding

This study forms part of a Professional Doctorate in Sport and Exercise in the School of Sport and Exercise at the University of Gloucestershire. Ethical approval has been granted by the University's ethics board. No external funding has been obtained for this research project. If you have any concerns regarding the ethics of this study or otherwise, please contact the University REC Chair, Dr Emily Ryall, [redacted].

Kind regards

Alex Sheldon

Professional Doctorate candidate: School of Sport and Exercise

University of Gloucestershire

Oxstalls Campus, Gloucester, GL2 9HW

[redacted]

Participant informed consent agreement

I [name] have read and understood the information on pages 1 and 2 of this form. I acknowledge that I have the opportunity to ask further questions using the contact details within this form and to withdraw my participation at any point.

I can also confirm that I have taken part in the anonymous survey prior to undertaking the interview.

I will work with the named researcher to arrange a suitable date and time for the remote or face-to-face interview.

Signed [name]

Date [date]

8.4 Appendix 4 - Interview / Co-Production questions guide

8.4.1 Post survey follow-up interview with coaches of female footballers

1. Preliminaries regarding consent – opportunity of interviewee to ask any questions
    a. Recording – will delete post completion of degree
    b. Anonymous, but will collect club names – they won't appear in final write up – area might
    c. Age, age group, years' experience,

Set video and phone to record

2. Tell me a little bit about your coaching past to date, how did you end up coaching the group(s) that you currently coach?

3. Any specific experience / achievement stand-out?

4. So, when you are coaching, and watching your players perform, what type of things are you looking for? What do you pick up?

5. (If they don't mention movements) - So you're looking for the quality of play/performance/enjoyment? What about how they move? Is there anything you notice on how your players move around the pitch or perform certain actions like running?

6. Do you think it is important to pay attention to how your players move, and if so, why?

7. So, you mentioned injury? Can you give me a bit of background on injury of your players? What type of injuries do you normally see and how do you deal with them?

8. What have you done/or seen previously, if anything, that tries to improve how your players move around the pitch?

9. And what about trying to identify those you think are at a higher risk of injury? Have you previously subconsciously noted players who you think are at higher risk? Is there anything you did about that player?

"So my project is trying to develop a movement screening tool to be used to identify female players who move a little different. This might have implications for injury risk or performance. This is what I mean by "movement screening". An example of a movement screen could be looking at someone's knee when they land and seeing how the knee moves, whether it moves inwards go outwards".

10. Thinking of movement screens then, why might you use them?

11. What would help you use movement screens with your players

12. Why might you NOT use them? What would stop you?

13. What could be done to increase your confidence using a movement screen with your players in the short and long-term?

14. If you were to undertake training to help you use movement screens, what would that training look like to you? And why?

15. Is there anything else that you would like to add?

8.4.2 Co-production areas for discussion

1. What areas of the body would you want the screening tool to concentrate on?
2. Modality of session(s)
3. In-session activities
4. Session timings
5. Material and equipment for the session
6. Post-season activities and ongoing support
7. Post NST actions
8. Are there any other recommendations or comments you want to give about the CPD session or the screening tool in general?

8.5 Appendix 5 - Ethical approval for oNST

School of Natural, Social & Sport Sciences Research Ethics Panel
Francis Close Hall
Swindon Road
Cheltenham
GL50 4AZ

nssethics@glos.ac.uk

A The Park
Cheltenham
GL50 2RH
T +44 (0) 3330 14 14 14
W glos.ac.uk

Date: 05/03/2024

Dear Alex Sheldon

Thank you for your application to the School of Natural, Social & Sport Sciences – School Research Ethics Panel (NSS-SREP).

Following institutional ethical review, I am pleased to confirm ethical clearance.

Please keep a record of this letter as a confirmation of ethical approval for your study (detailed below), reviewed by the School Research Ethics Panel of the School of Natural, Social & Sport Sciences, University of Gloucestershire, on 28th February

Project Title:	Creating a novel lower-limb screening tool for use by grassroots coaches of female adolescent footballers
Start Date:	Jan, 2024
Projected Completion Date:	Jun, 30th 2024
NSS-REP Clearance code:	NSSS.SPRT.05032402

If you have any questions about ethical clearance, please feel free to contact me. Please use your SREP clearance code in any future correspondence regarding this study.

Kind Regards

[redacted]

School Research Ethics Lead

School of Natural, Social & Sport Sciences

8.6 Appendix 6 - Ethical approval for inNST

School of Natural, Social & Sport Sciences Research Ethics Panel
Francis Close Hall
Swindon Road
Cheltenham
GL50 4AZ

edsethics@glos.ac.uk

A The Park
Cheltenham
GL50 2RH
T +44 (0) 3330 14 14 14
W glos.ac.uk

Date: 04.04.24

Dear Alex Sheldon

Thank you for your application to the School of Natural, Social & Sport Sciences – School Research Ethics Panel (NSS-SREP).

Following institutional ethical review, I am pleased to confirm ethical clearance.

Please keep a record of this letter as a confirmation of ethical approval for your study (detailed below), reviewed by the School Research Ethics Panel of the School of Natural, Social & Sport Sciences, University of Gloucestershire, on 4th April, 2024

Project Title:	Creating a novel lower-limb screening tool for use by grassroots coaches of female adolescent footballers
Start Date:	April 2024
Projected Completion Date:	June 2024
NSS-REP Clearance code:	EDS.SPRT.03042401

If you have any questions about ethical clearance, please feel free to contact me. Please use your SREP clearance code in any future correspondence regarding this study.

Kind Regards

[redacted]

School Research Ethics Lead

School of Natural, Social & Sport Sciences

8.7 Appendix 7 - Protocols for screens continued within the NST CPD session

Protocols devised from Fältström et al., 2021; Ko et al., 2020; Kotsifaki et al., 2022; McCunn et al., 2017.

- Participants given three practice attempts for each screen, during which any obvious miscommunication or misunderstandings about how to perform the movements to be clarified.

8.7.1 Anterior Reach protocol

Set up	**Protocol**
Mark a starting position for the player	After a standard football warm-up; • Player stands on one foot • Player reaches forward as far as possible to front • Slight a little toe touch at full reach before returning to the starting position • After completing, player swaps legs and repeat • Measure the distance of each attempt on each leg • For more accuracy, repeat the test three times in each direction on each leg, using the greatest distance achieved as the score for that direction and leg.
Rules	**Scoring**
The trial is suspended and repeated if the player • Player fails to maintain the balance on the standing limb, • Player lifts or moves the standing foot from the centre of the grid,	• A distance for each measure for both legs is recorded • Players that show a difference on the Anterior reach direction (1) of greater than 4cm would be recommended to

• Player's reach toe does not contact the floor, • Player fails to return the reach foot to the starting position, or • Player loses balance and plants the reach foot on the floor	complete further neuromuscular training. • Additionally, note any differences between left/right leg. Was the player able to complete on both legs equally, did they need a few tries on one leg compared to the other, etc.

8.7.2 Single Leg Hop for Distance protocol

Set up	**Protocol**
• Mark a starting position for the player	After a standard football warm-up; • Player places hands on hips • Stands in an upright position on one leg • Perform a forward counter-movement hop as far of possible. • Landing on same foot, holding the landing for 3 seconds • Measure the distance from the start line to the heel of the landing foot • Repeat on the other leg
Rules	**Scoring**
The trial is suspended and repeated if the player • Player removes their hand from their hips • Player cannot hold the landing position for 3 seconds	• Measure the distance from the start line to the heel of the landing foot • Record the scores for each leg and calculate the Limb Symmetry Index (LSI) for each leg • LSI1 = (left leg divided by right leg) x 100 • LSI2 = (right leg divided by left leg) x 100 • If player score <90% on either LSI1 or LSI2 they would be recommended to complete further neuromuscular training.

8.7.3 Modified Tuck Jump Assessment protocol

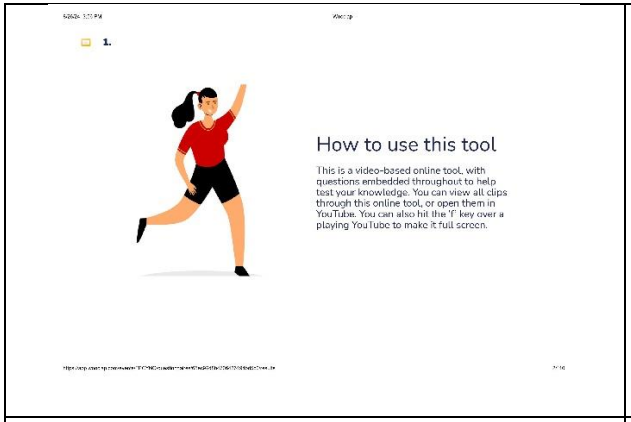
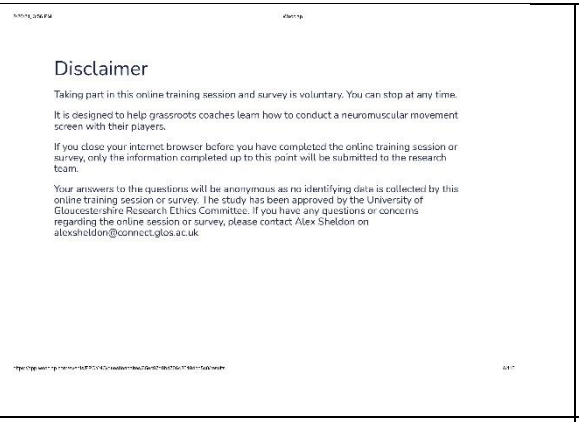
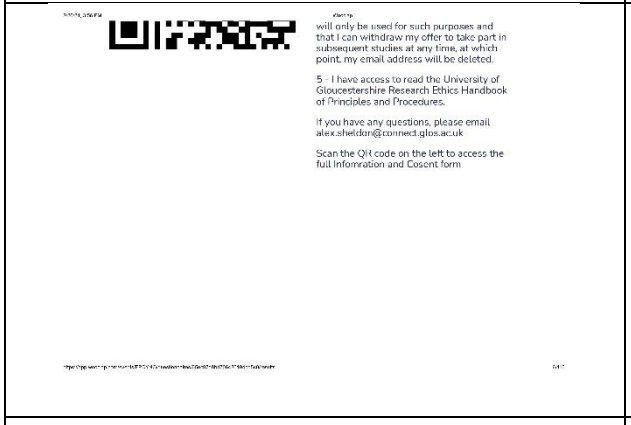
Set up	Protocol
• Place a marker on the floor, draw out a box with tape • If using a smartphone(s) to record the actions, place one in front of the player. If two smartphones, one can be placed looking side on at the player. If one smartphone and still want to record, player can repeat the jump protocol twice, moving the smartphone between attempts.	After a standard football warm-up; • Player to perform repeated tuck jumps for 10 seconds. • Instruct player to lift knees to hip hide and attempt to land in the same place each time • Instruct player not to pause between jumps.
Rules	**Scoring**
The trial is suspended and repeated if the player • If player cannot complete the mTJA jump for a total of 10 seconds • If player cannot start and land the same area	• Lower extremity valgus at landing = 1 point per limb • Thighs not reaching parallel to the ground = 1 point per limb • Thighs not equal side to side = 1 point • Keep a record other the scores. Any player that scores on the above criteria would be recommended to complete further neuromuscular training.

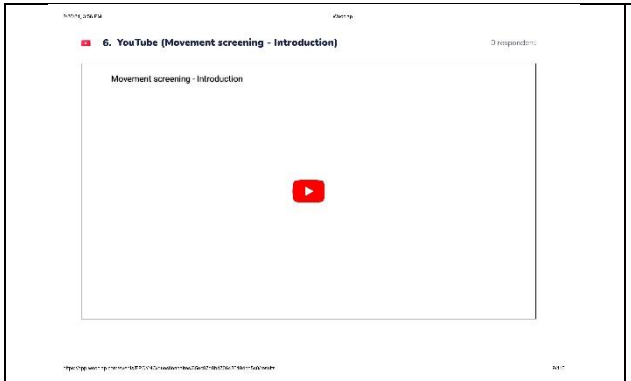
8.8 Appendix 8 – Wooclap QR codes for and screenshots of the oNST

8.8.1 QR codes to access the oNST and individual YouTube clips. Weblinks are embedded below

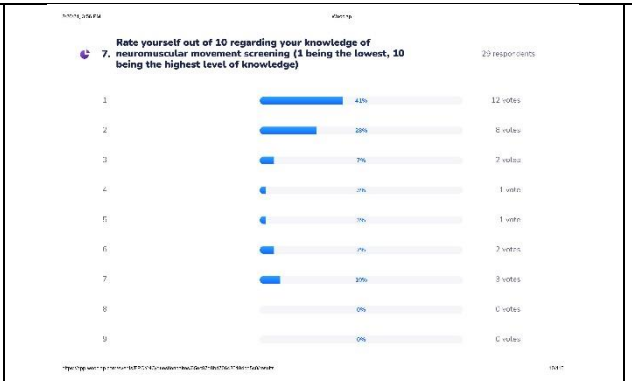
	QR code to access the oNST (including videos questions)
	Introduction to the oNST
	Key terms used throughout oNST and inNST
	Anterior Reach protocol
	Single Leg Hop for Distance protocol
	Modified Tuck Jump Assessment protocol

8.8.2 oNST screenshots (from Wooclap – including responses)

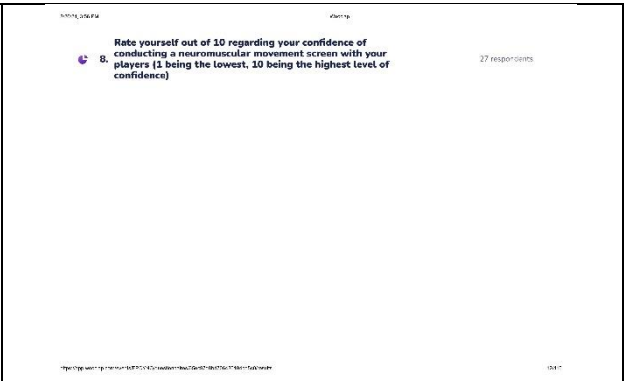
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6. YouTube (Movement screening - Introduction)
Movement screening - Introduction

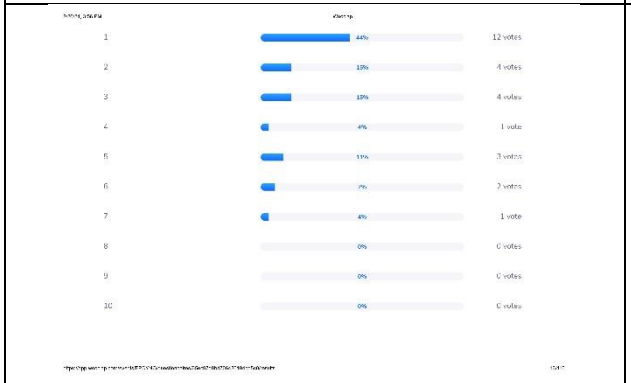
7


7. Rate yourself out of 10 regarding your knowledge of neuromuscular movement screening (1 being the lowest, 10 being the highest level of knowledge)
29 respondents
1 41% 12 votes
2 28% 8 votes
3 7% 2 votes
4 3% 1 vote
5 3% 1 vote
6 7% 2 votes
7 10% 3 votes
8 0% 0 votes
9 0% 0 votes

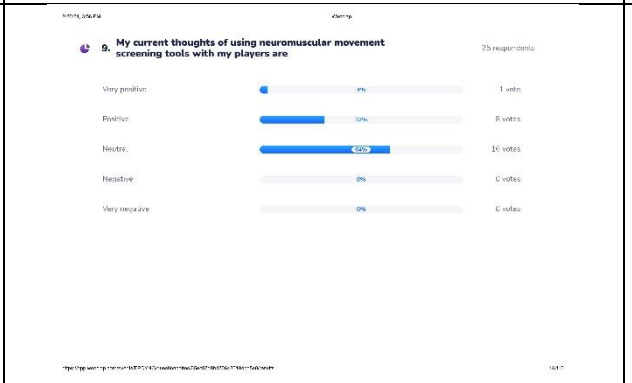
8


8. Rate yourself out of 10 regarding your confidence of conducting a neuromuscular movement screen with your players (1 being the lowest, 10 being the highest level of confidence)
27 respondents

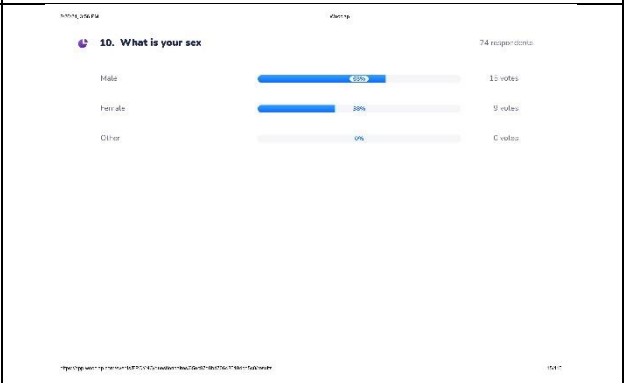
9


1 44% 12 votes
2 15% 4 votes
3 15% 4 votes
4 4% 1 vote
5 11% 3 votes
6 7% 2 votes
7 4% 1 vote
8 0% 0 votes
9 0% 0 votes
10 0% 0 votes

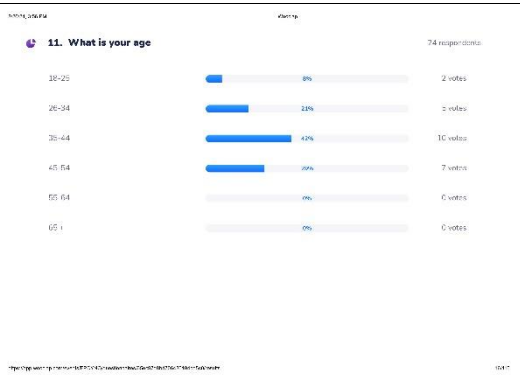
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9. My current thoughts of using neuromuscular movement screening tools with my players are
Very positive 4% 1 vote
Positive 30% 8 votes
Neutral 60% 16 votes
Negative 0% 0 votes
Very negative 0% 0 votes

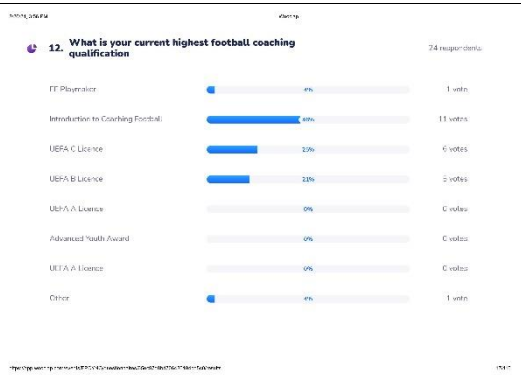
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10. What is your sex
74 respondents
Male 65% 13 votes
Female 35% 9 votes
Other 0% 0 votes

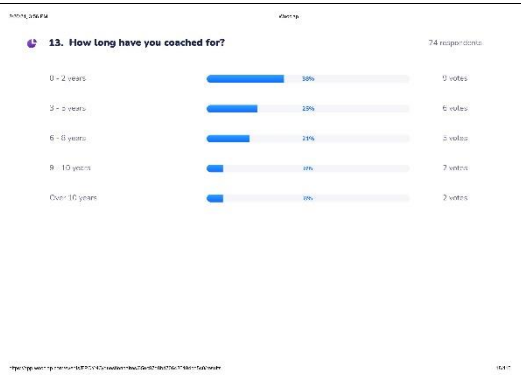
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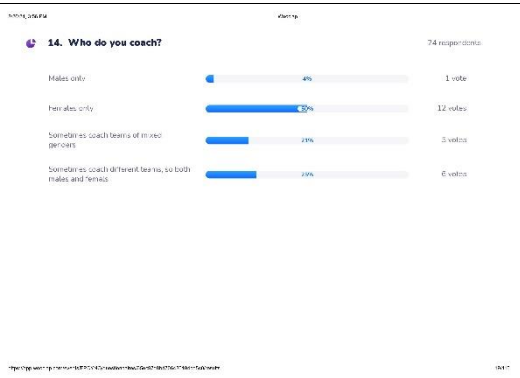
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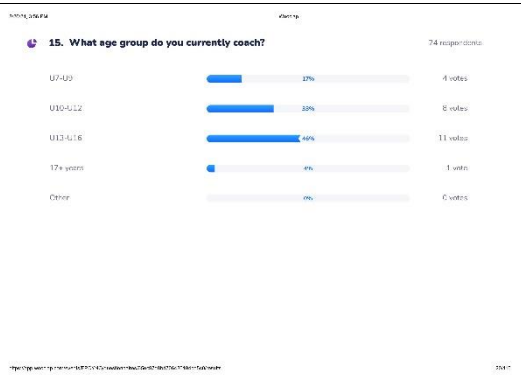
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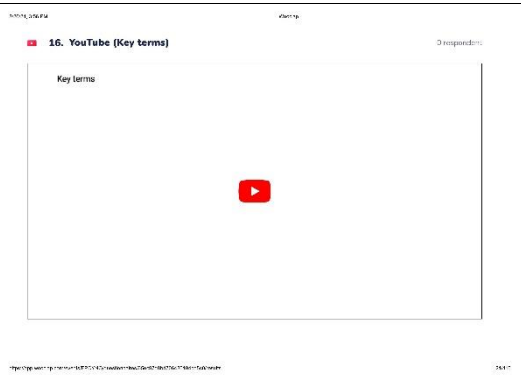
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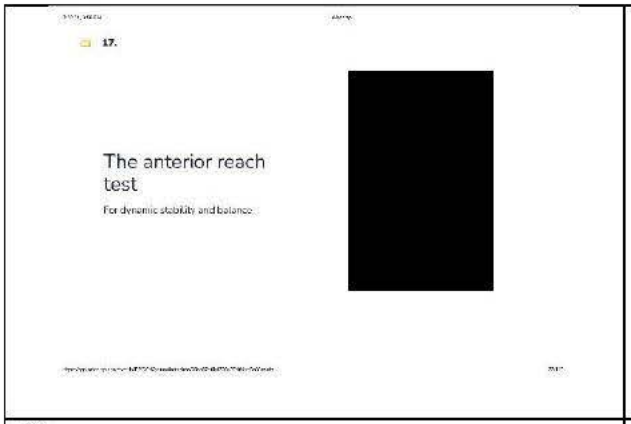
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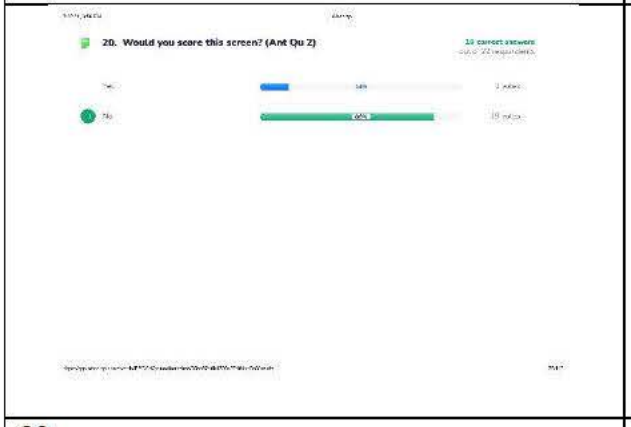
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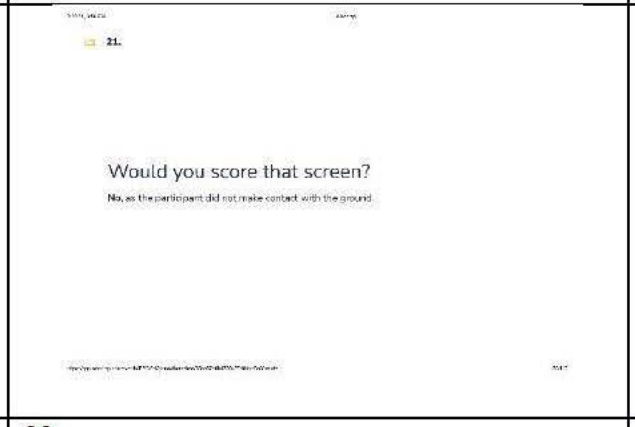
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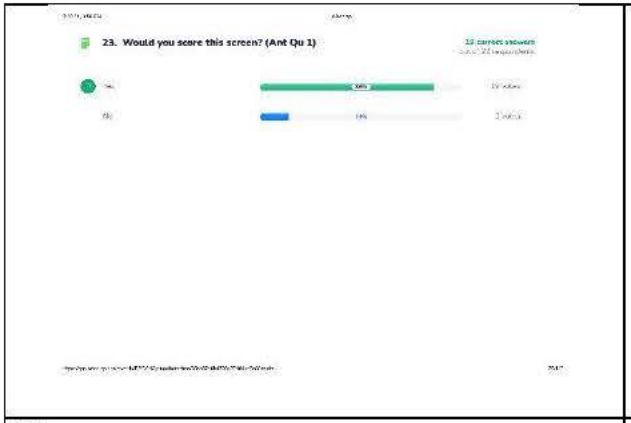
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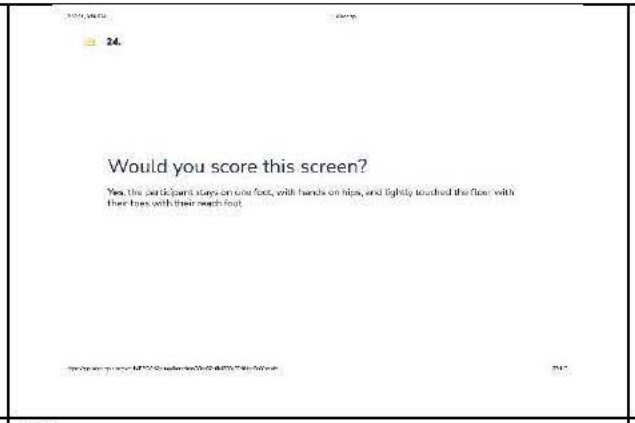
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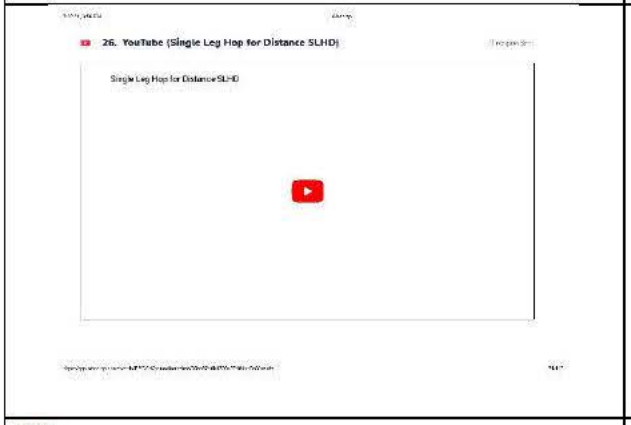
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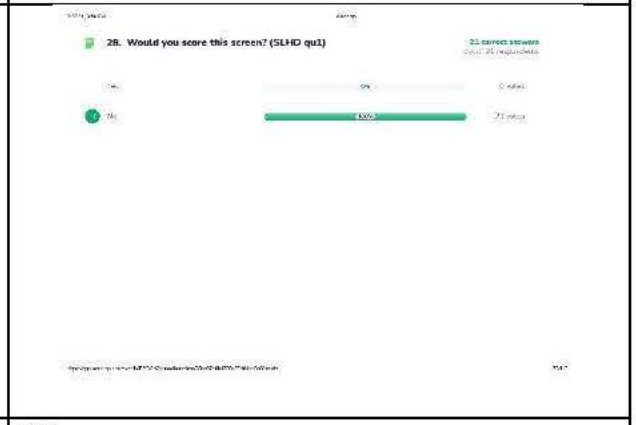
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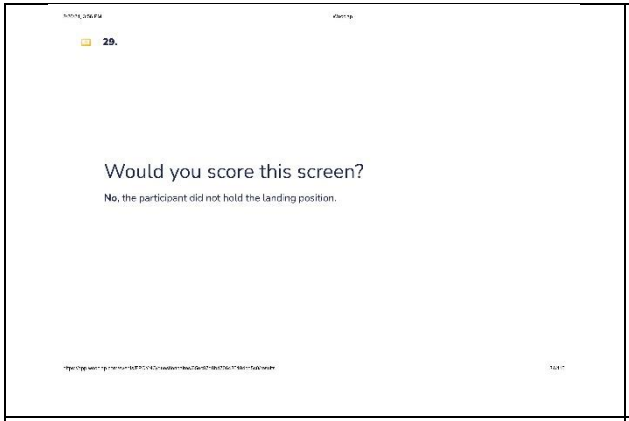
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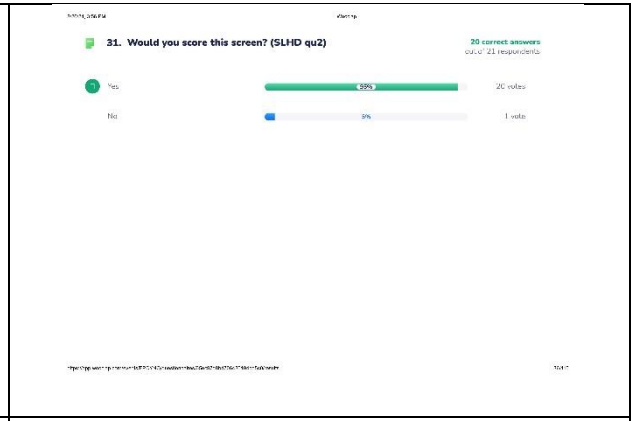
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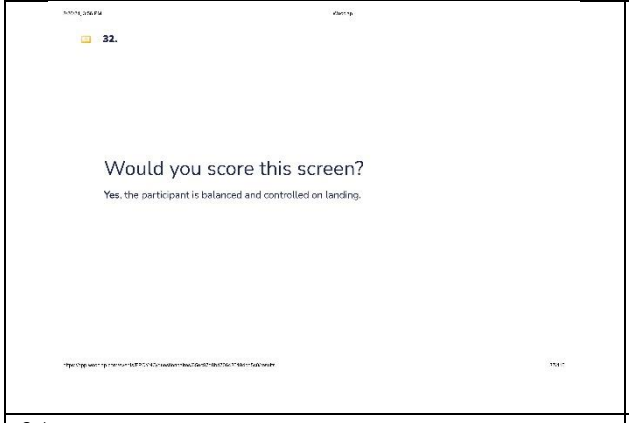
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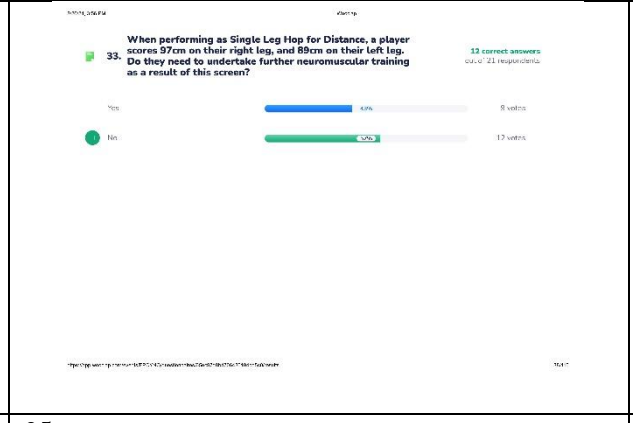
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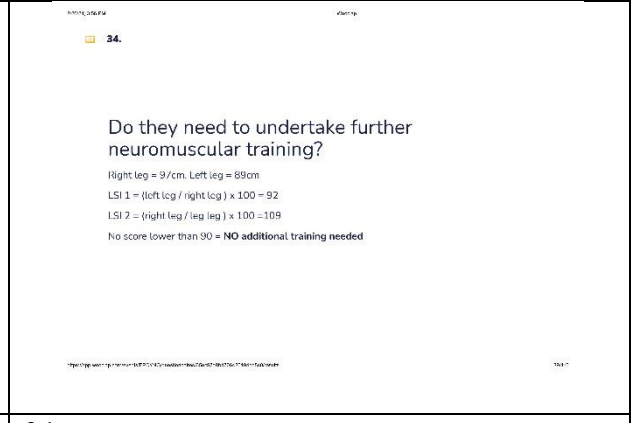
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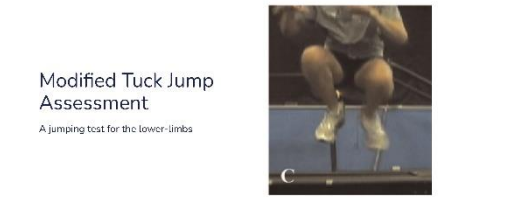
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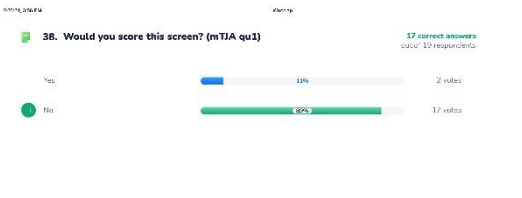
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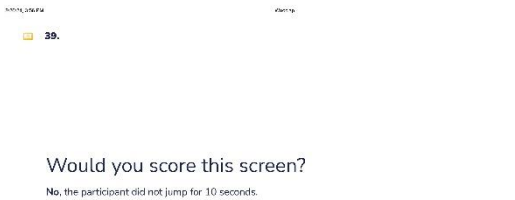
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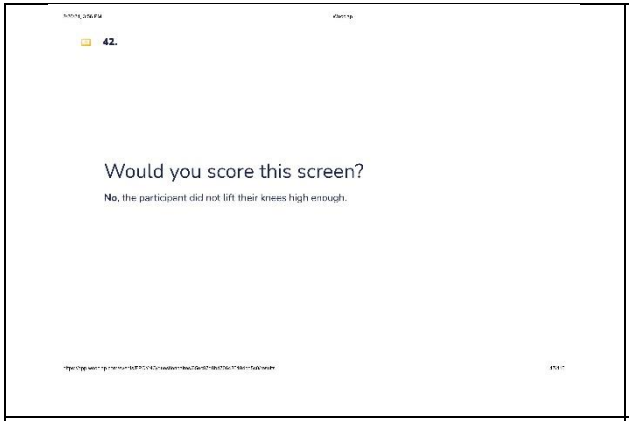
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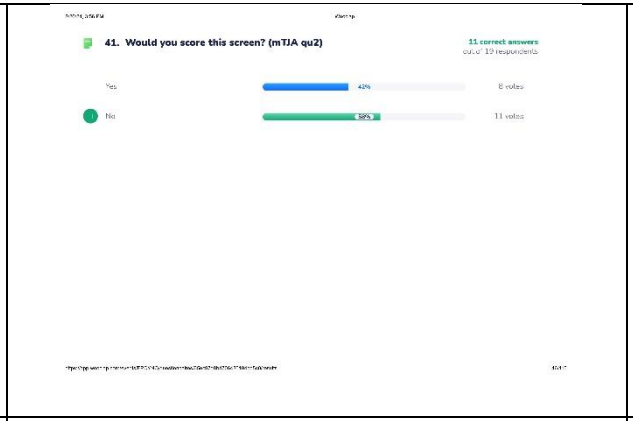
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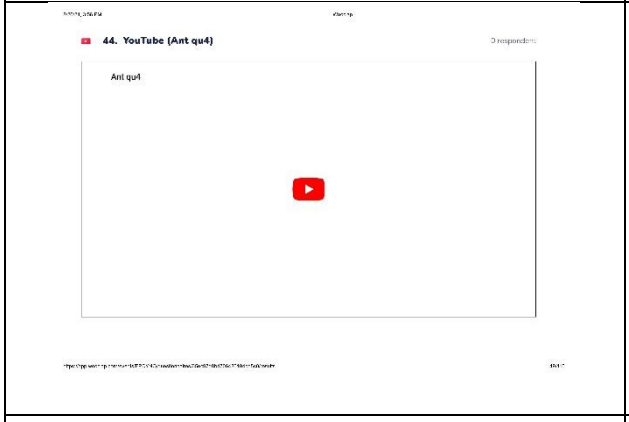
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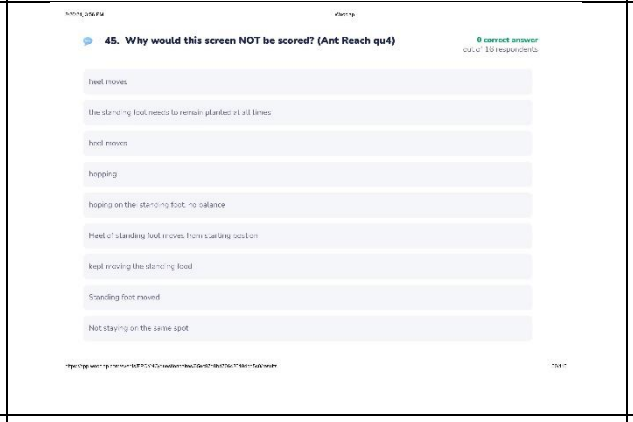
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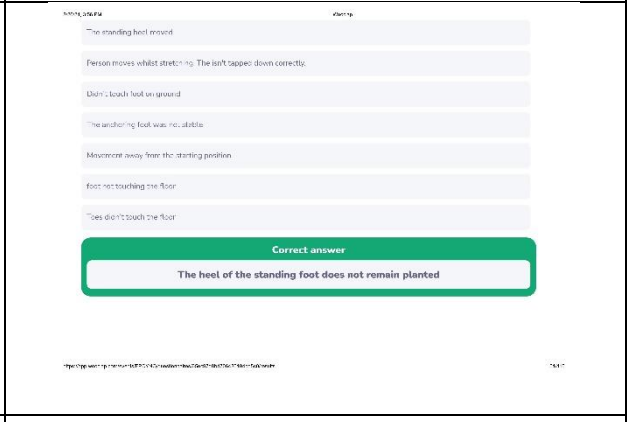
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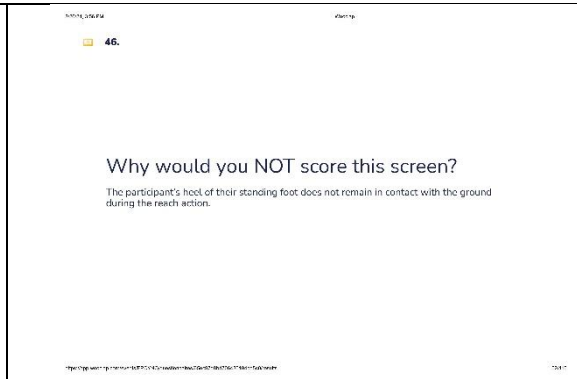
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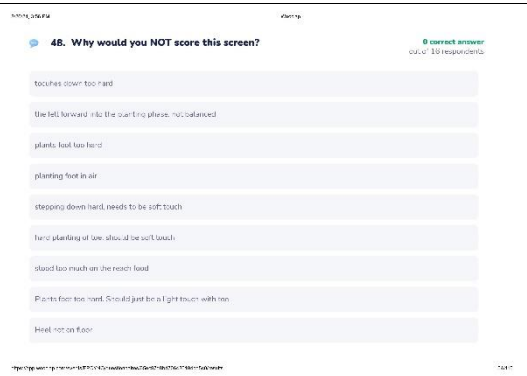
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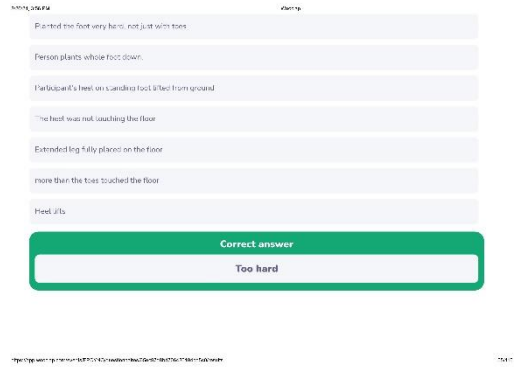
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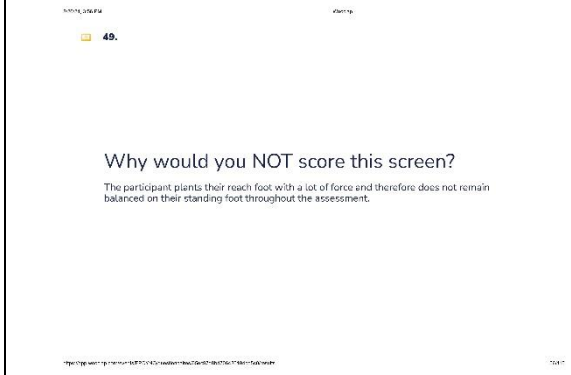
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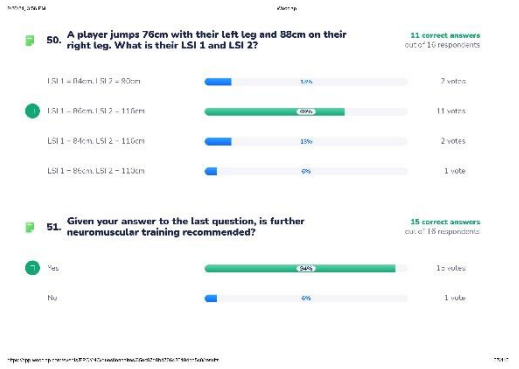
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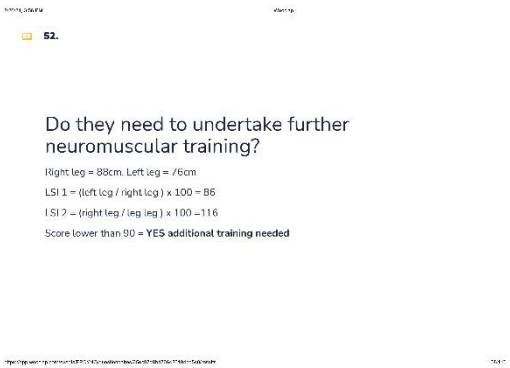
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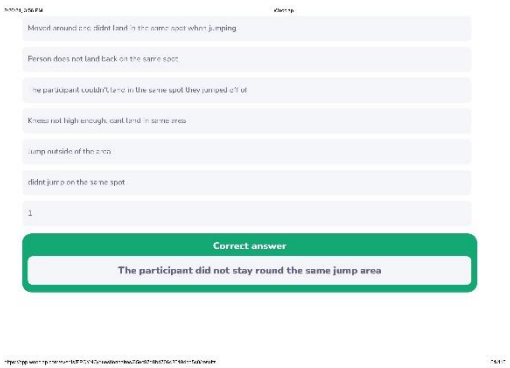
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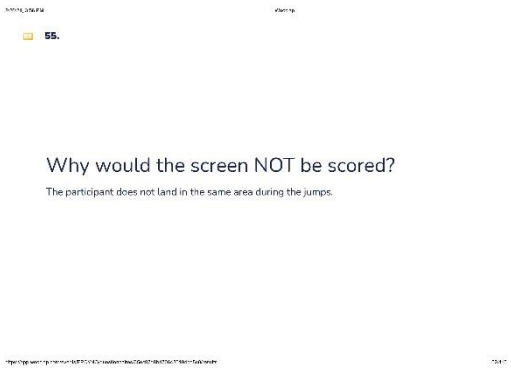
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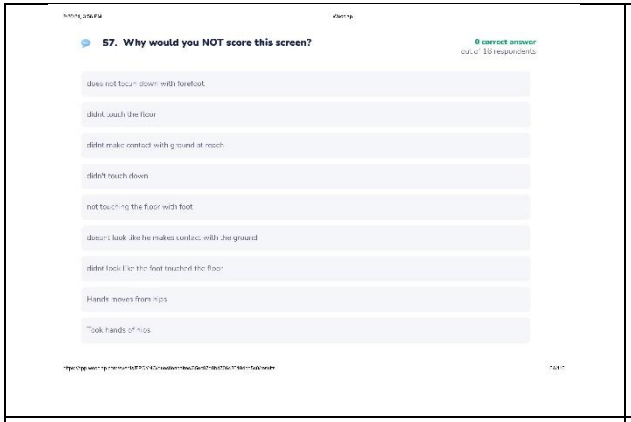
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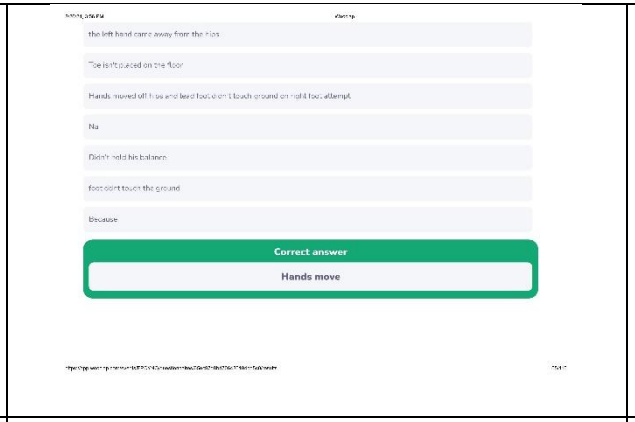
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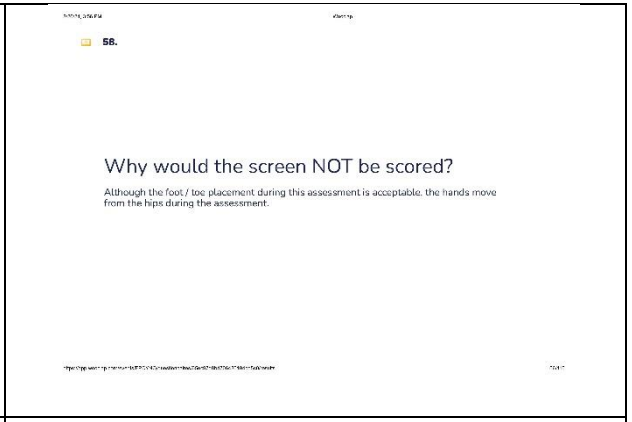
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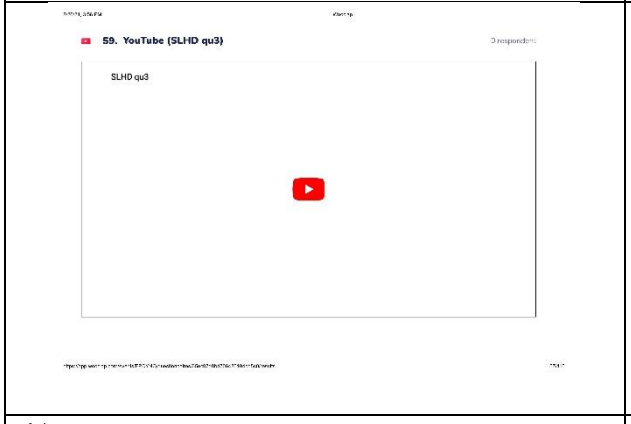
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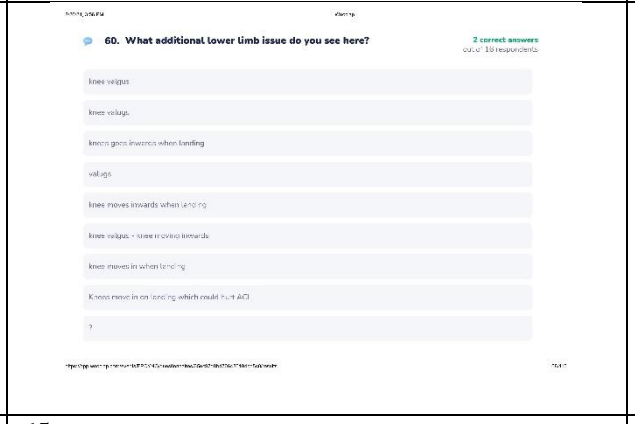
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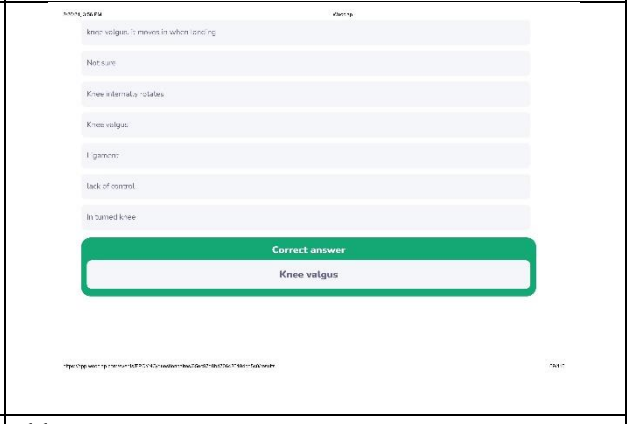
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64



65

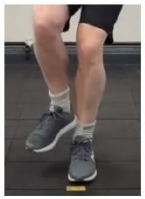


66

61.

What additional lower limb issue do you see here?

Knee valgus is displayed upon impact. At the moment of impact you can see that the knee of the landing foot quickly moves inwards towards the midline of the body.



67

62. YouTube (SLHD qu4)

SLHD qu4

68

63. Why would you NOT score this screen?

0 correct answer

out of 19 respondents

the can't balance on landing without using arms

hands moved off hips during jump

Hands should stay on hips when jumping and landing. His moved.

hands move from hips

they move their hands when jumping

no, hands should remain on hips during landings. He moved

hands move from hips

When landing the hands need to stay on hips. His moved

Took hands off hips

69

nop, both hands move away from hips

Hands leave the hips

Hands moved off hips

Hands move from hips

Didn't hold his finish

hands come off hips

does hands off hips so lack of balance

Correct answer

Hands move

70

64.

Why would the screen NOT be scored?

Although the landing is held and controlled, the hands move from the hips during the assessment.

71

65. A participant reaches 30cm on their right leg and 36cm on their left leg during the Anterior Reach Test. Why would they be advised to undertake further neuromuscular training?

0 correct answer

out of 19 respondents

difference between right and left legs can be more than 4cm, this is 6cm.

as its bigger than 4cm diff between limbs

should be no greater than 4cm between sides

yes as its >4cm diff

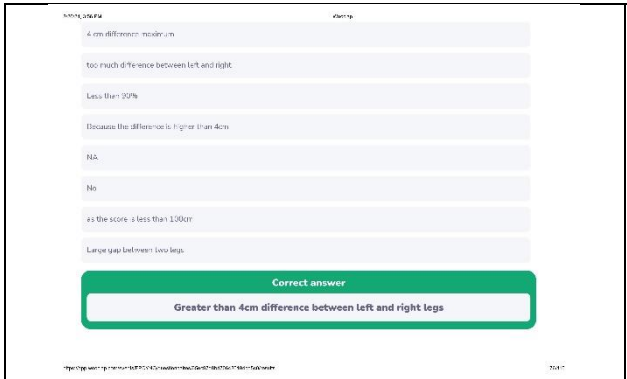
yes, needs to be under 4cm

greater than 4cm difference

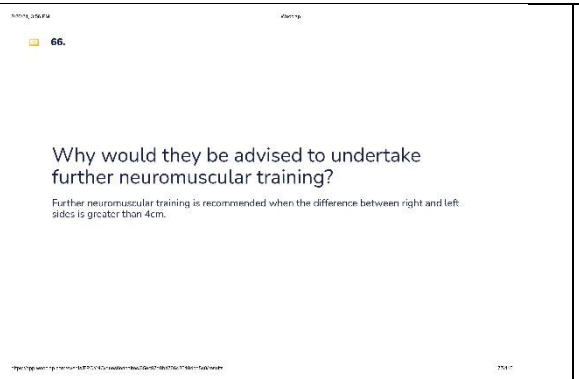
left leg is 83% <80%

Not good at maths

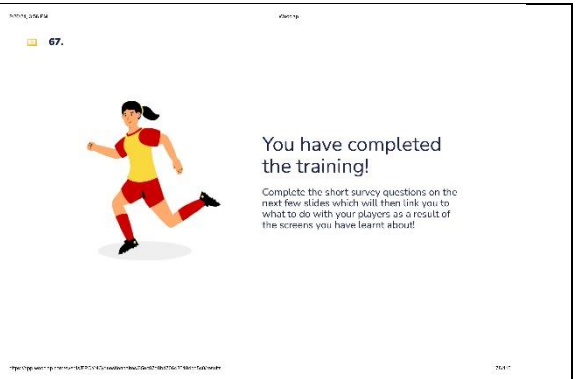
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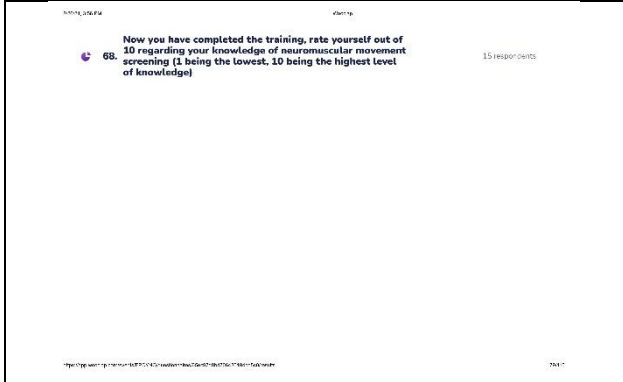
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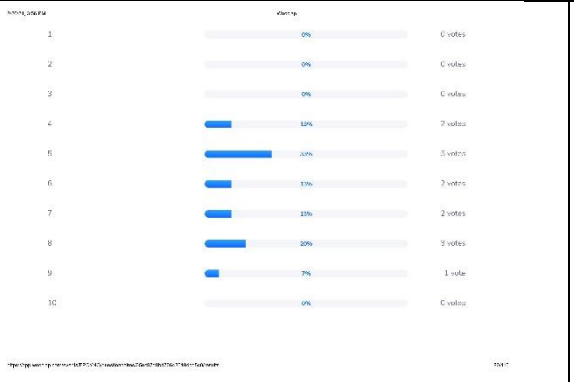
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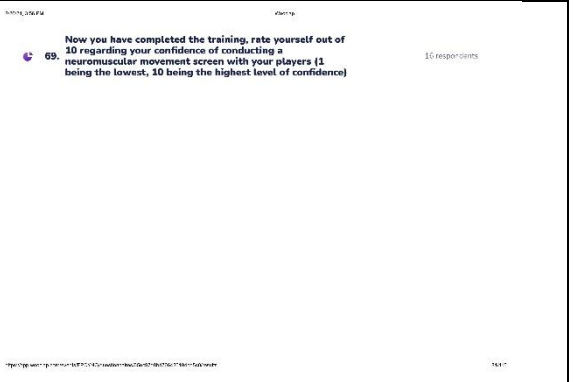
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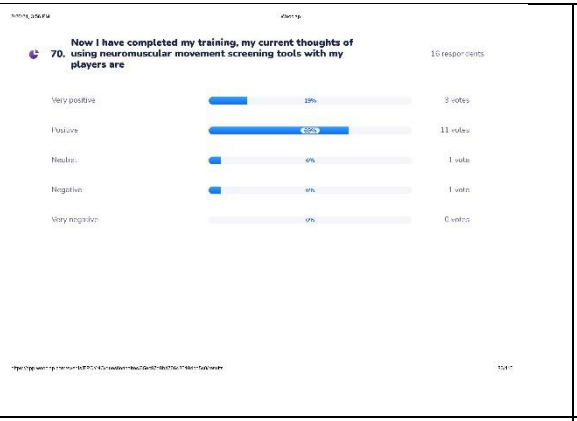
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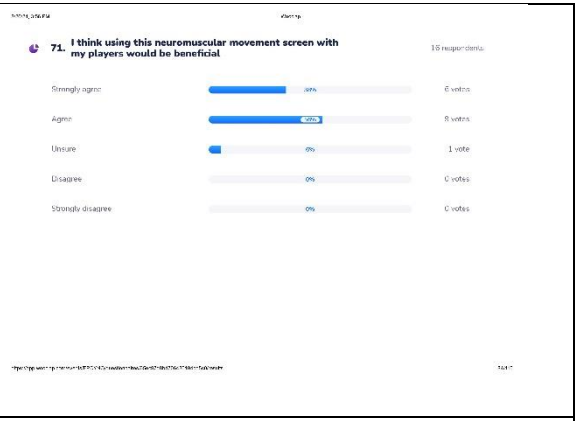
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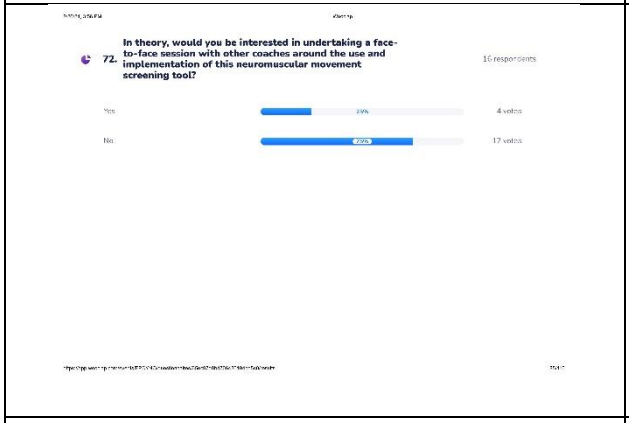
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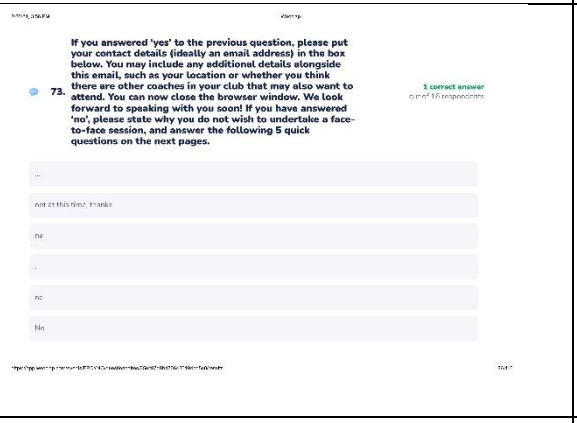
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81



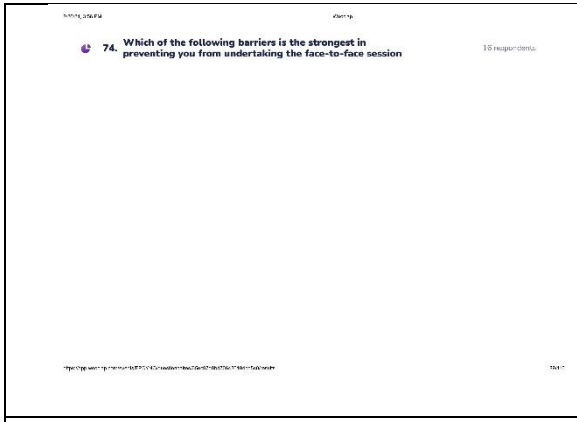
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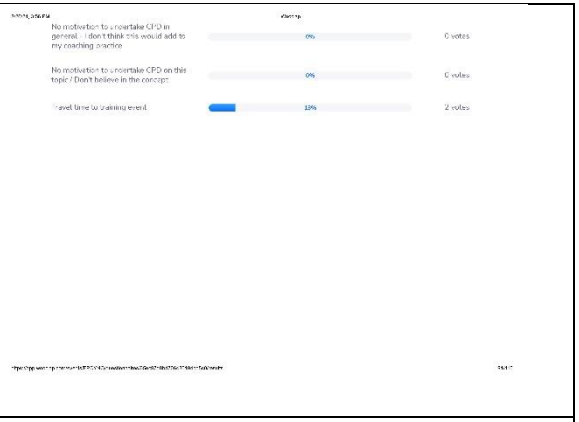
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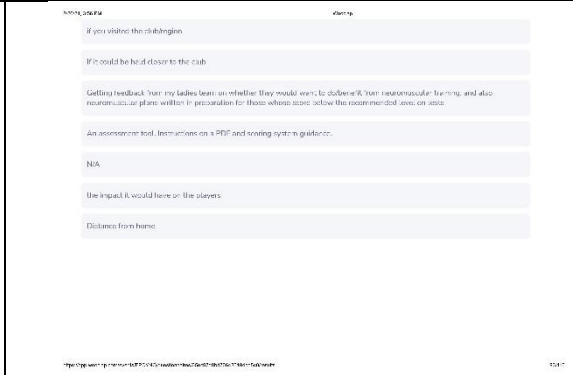
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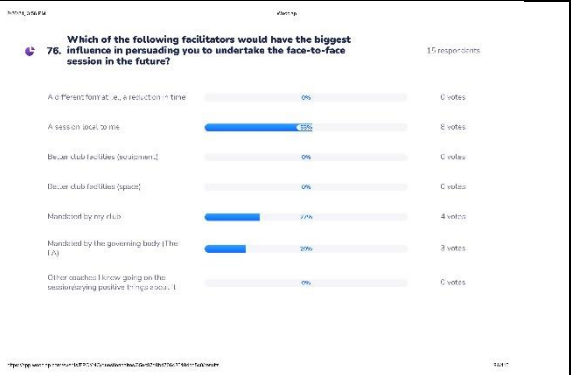
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88



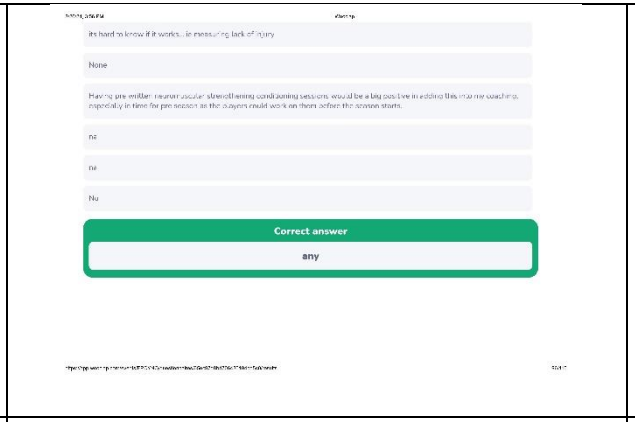
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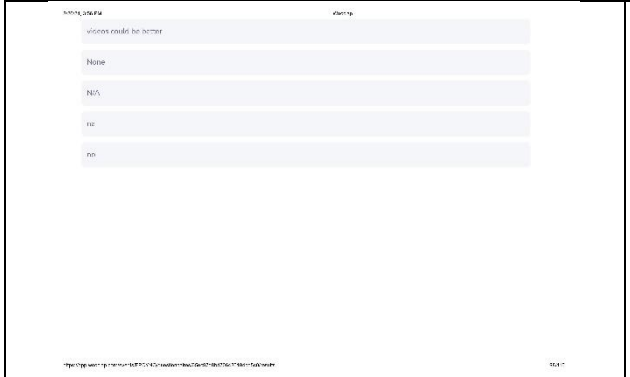
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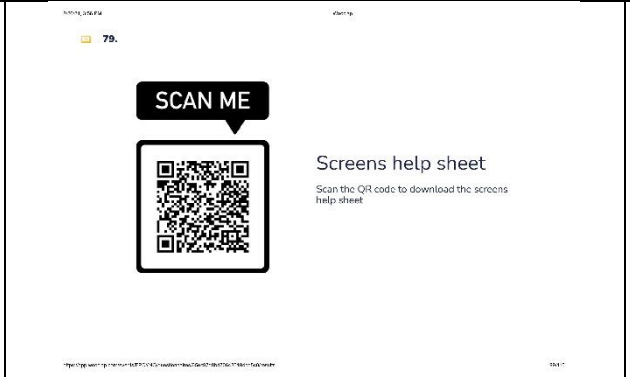
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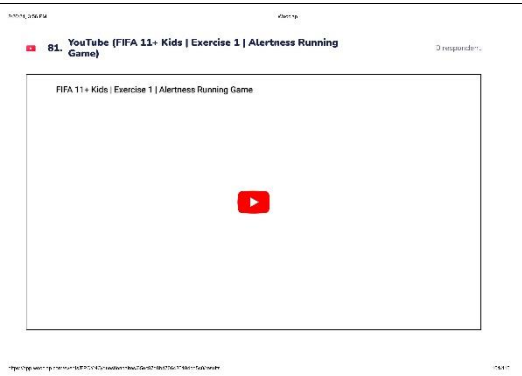
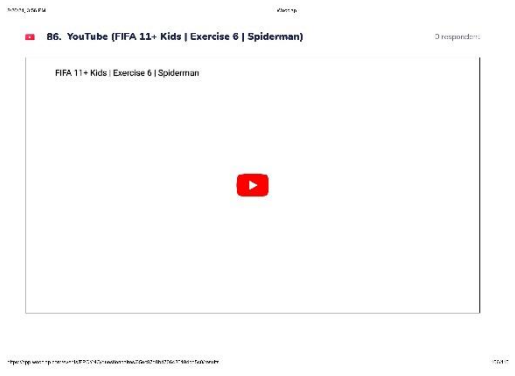
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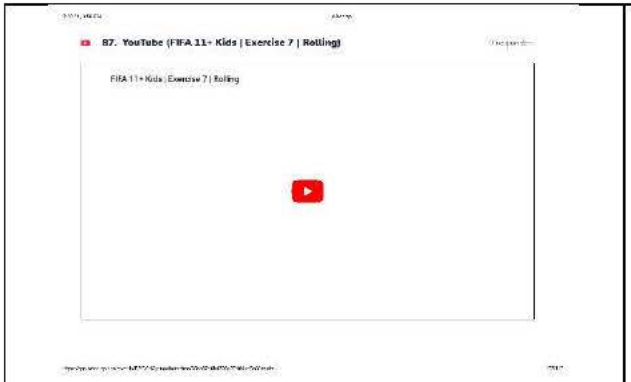


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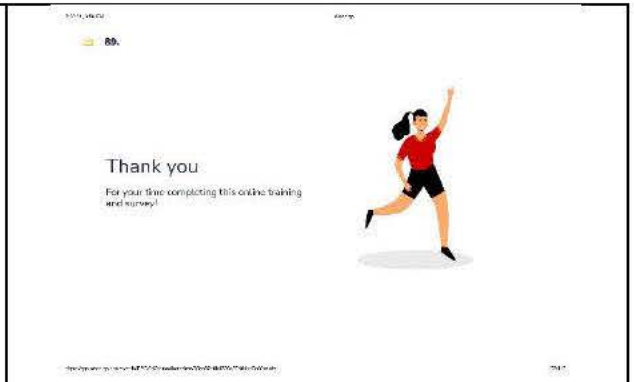
		
97	98	99
		
100	101	102


87. YouTube (FIFA 11+ Kids | Exercise 7 | Rolling)
FIFA 11+ Kids | Exercise 7 | Rolling

103


88.
FIFA 11+ booklet??
Scan the QR code to get a PDF of the FIFA 11+ Kids (its chunky, but has everything you need... or use the YouTubes!)

104


89.
Thank you
For your time completing this online training and survey!

105

8.9 Appendix 9 – Additional help sheet from oNST

Slide 1

The Anterior Reach (1)

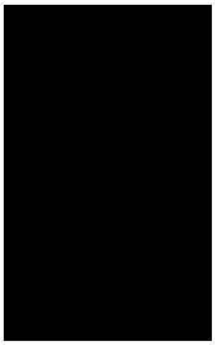
What is it?

The Anterior Reach test is a reliable and easy test used to assess dynamic stability and balance. This means that this screen measures range of motion, flexibility, neuromuscular control and strength all at once.

What do you need?

To run this test you will need;

- A tape measure
- Tape or a marker, such as plasticine, a small cone, or even just a pen
- Ideally something for measuring angles for ease of use, you can download an app for your smartphone
- Something to write down the score on



How to set up

- Find a line or marker! Get the player to stand on the line or marker. That's it!

How to test

After a standard football warm-up;

- Ask the player to stand on one foot, with their hands on their hips, facing forwards
- They reach forward as far as possible to the front
- They reach as far as possible, with a little toe touch at full reach before returning to the starting position
- After completing, players swap legs and repeat
- Measure the distance of each attempt on each leg
- For more accuracy, if time allows repeat the test three times in each direction on each leg, using the greatest distance achieved as the score for that direction and leg.

Slide 2

The Anterior Reach (2)

Rules

The trial is suspended and repeated if the player

- Fails to maintain the balance on the standing limb,
- Lifts or moves the standing foot from the centre of the grid,
- The reach toe does not contact the floor,
- Fails to return the reach foot to the starting position, or
- Loses balance and plants the reach foot on the floor

How to score

- A distance for each measure for both legs is recorded
- Players that show a difference on the Anterior reach direction (1) of greater than 4cm would be recommended to complete further neuromuscular training.
- Additionally, note any differences between left/right leg. Was the player able to complete on both legs equally, did they need a few tries on one leg compared to the other, etc.

Slide 3

Single Leg Hop for Distance (1)

What is it?

As the name suggests, the SLHD is a one-legged hop, with players trying to achieve the greatest distance. It can help assess differences in leg strength between right and left legs.

What do you need?

To run this test you will need;

- A marker to jump from, such as tape or some rope.
- A measuring tape
- Something to write down the score on
- A calculator for the results



How to set up

- Find a line or marker! Get the player to stand on the line or marker. That's it!

How to test

After a standard football warm-up;

- Get the player to place their hands over their hips
- Stand in an upright position on one leg
- Perform a forward counter-movement hop as far of possible. A counter-movement jump is where there is a bend in the leg immediately prior to a jump
- Land on the foot of the same leg, holding the landing for 3 seconds
- Measure the distance from the start line to the heel of the landing foot
- Repeat on the other leg

Slide 4

Single Leg Hop for Distance (2)

Rules

The trial is suspended and repeated if the player

- Removes their hand from their hips
- Cannot hold the landing position for 3 seconds

How to score

- Measure the distance from the start line to the heel of the landing foot
- Record the scores for each leg and calculate the Limb Symmetry Index (LSI) for each leg
- LSI1 = (left leg divided by right leg) x 100
- LSI2 = (right leg divided by left leg) x 100
- If a player scores <90% on either LSI1 or LSI2 they would be recommended to complete further neuromuscular training.

How to score – example 1

Left leg jump = 90cm

Right left jump = 92cm

LSI1 = (90/ 92) * 100 = 97.8

LSI2 = (92/ 90) * 100 = 102

= No additional training required

How to score – example 2

Left leg jump = 75cm

Right left jump = 85cm

LSI1 = (75 / 85) * 100 = **88.2**

LSI2 = (85/ 75) * 100 = 111.3

= Additional training required

Slide 5

Modified Tuck Jump Assessment (1)

What is it?

The Tuck Jump is a very comment method of assessment in sport. However, the amount of scoring criteria (10 in total) makes it harder to complete when time is short. A modified version of the tuck jump assessment (mTJA) can focus on the actions that are most relevant to football and that have been linked to decreased performance and increased injury risk.

What do you need?

To run this test you will need;

- Something to mark the start/landing zone such as tape
- Something to write the result on
- The use of a smartphone etc to record the jumps might make it easier for you to score.

How to set up

- Place a marker on the floor, ideally a straight line, or draw out a box with tape
- If you are using a smartphone(s) to record the actions, place one in front of the player. If you have two smartphones, one can also be placed looking side on at the player. If you only have one smartphone and still want to record, you can get the player the repeat the jump protocol twice, moving the smartphone between attempts.

How to test

After a standard football warm-up;

- Ask the player to perform repeated tuck jumps for 10 seconds.
- Instruct the player to lift knees to hip hide and attempt to land in the same place each time
- Instruct the player not to pause between jumps.

Slide 6

Modified Tuck Jump Assessment (2)

Rules

The trial is suspended and repeated if the player

- If the player cannot complete the mTJA jump for a total of 10 seconds
- If the player cannot start and land the same area

How to score

- Lower extremity valgus at landing = 1 point per limb
- Thighs not reaching parallel to the ground = 1 point per limb
- Thighs not equal side to side = 1 point
- Keep a record other the scores. Any player that scores on the above criteria would be recommended to complete further neuromuscular training.



- Lower extremity valgus at landing – where one or both knees collapse inwards on landing

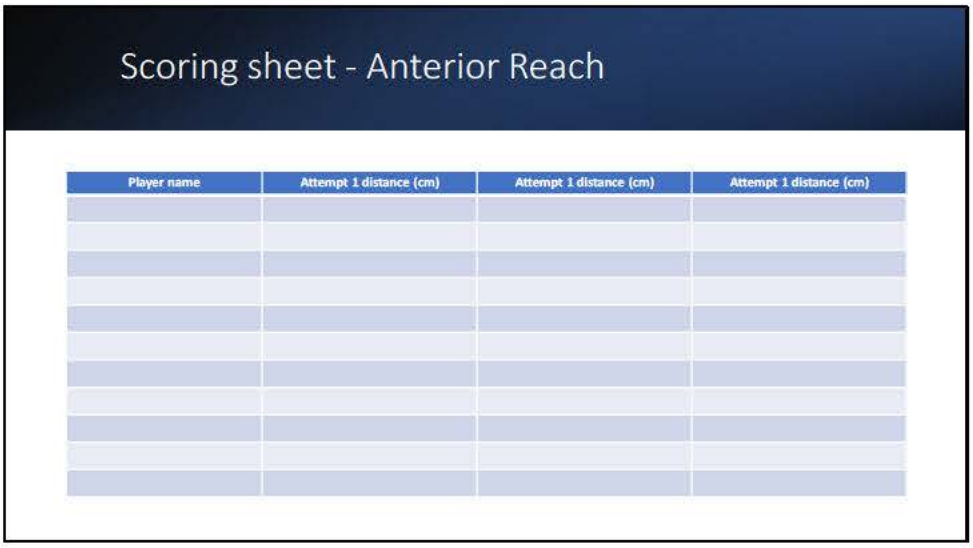


- Thighs not equal side to side

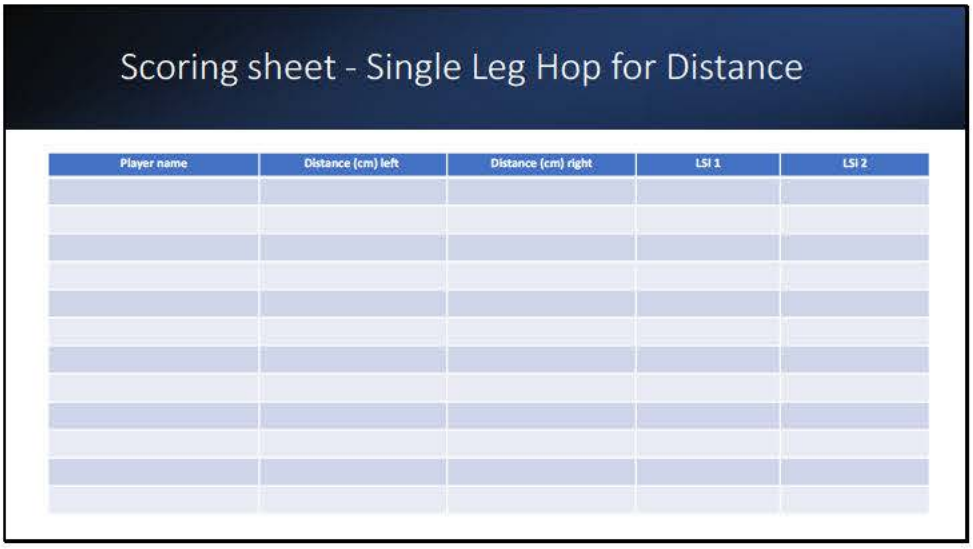


- Thighs not reaching parallel to the ground

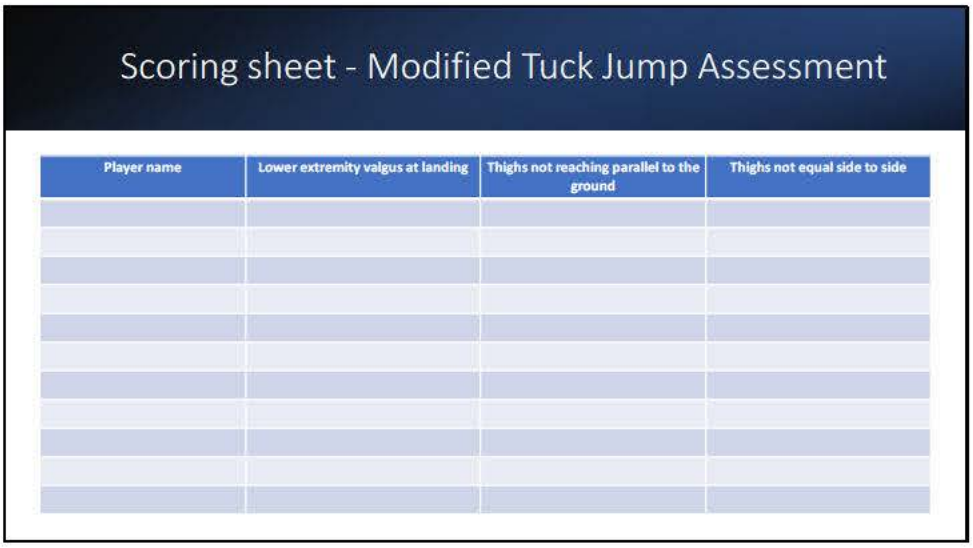
Slide 7



Slide 8



Slide 11


Scoring sheet - Modified Tuck Jump Assessment
Player name
Lower extremity valgus at landing
Thighs not reaching parallel to the ground
Thighs not equal side to side

8.10 Appendix 10 - Research Participants Privacy Notice - University of Gloucestershire

Research Participants Privacy Notice - Last updated: 9 February 2022

In order to undertake academic research and to train students in research methods, staff and students at the University of Gloucestershire collect and process various types of personal data. The University is committed to being transparent about how it collects and uses that data and to meeting its data protection obligations.

1. Identity and contact details of the Data Controller

The Data Controller (the organisation responsible for how your data is processed) is the University of Gloucestershire. The University is registered with the Information Commissioner's Office and it is committed to protecting the rights of individuals in line with Data Protection legislation.

A copy of this registration can be found here.

2. Contact details of the Data Protection Officer

The Data Protection Officer is responsible for advising the University on compliance with Data Protection legislation and monitoring its performance against it. If you have any concerns regarding the way in which the University is processing your personal data, please contact the Data Protection Officer at:

Data Protection Officer

University of Gloucestershire, Registrar's Directorate

Fullwood House, The Park

Cheltenham, GL50 2RH

Email: dpo@glos.ac.uk

3. What information does the University collect?

The University collects a range of information in order to carry out its research activities. This may include personal data such as name and address, date of birth, or information on your views on specific research topics. The University may also collect special category (sensitive) persona l data as defined under Data Protection legislation such as information about racial or ethnic origin, political opinions, religious or similar beliefs, health, genetic or biometric data (where used for ID purposes).

The University collects this information in a variety of ways. For example, it might be collected via surveys or questionnaires, through interviews of focus groups, or by taking photographs, audio or video recordings.

For each individual research project you will be provided with a Participant Information Sheet, which explains in more detail the kind of information that will be collected, and how this will be done.

4. What is the purpose and lawful basis of collecting my data?

Undertaking research, publishing research and training students to undertaking are tasks that are in the public interest. Universities undertake these activities so that they can fulfil their function as a Higher Education institution. Some types of research will require the collection of personal data including, where appropriate, special category personal data, in order that the aims of the research can be achieved. The University will only collect the information that is necessary to undertake each specific research project. If we are able to anonymise or pseudonymise the personal data you provide we will undertake this, and will endeavour to minimise the processing of personal data wherever possible.

Where we rely on a different lawful basis such as consent or legitimate interest we will inform you of this in the Participant Information Sheet provided to you.

There is no statutory or contractual requirement to provide your personal data to us through participating in a research project.

The University will not use your personal data for automated decision making or profiling about you as an individual.

5. How and where your data are held

All research projects involving the collection of personal data are subject to an ethics review, to ensure that appropriate arrangements are made for the secure storage of your data. If you take part in a research project, you will be provided with a Participant Information Sheet that will outline in more detail how and where your data are stored.

6. Who has access to the data?

Your data will be accessed by members of the research team (including Supervisors of student research projects), however, most personal information used in research will be de-identified

where-ever possible before sharing more widely or publishing the research outcomes. If it is not possible to de-identify your information, we may ask for your consent to share or otherwise make your personal information available to others. Information shared will be on a need to know basis, not excessive and with all appropriate safeguards in place to ensure the security of your information. It may sometimes be necessary to share your personal information with other researchers for the purpose of achieving the research outcomes. Where researchers wish to use any information that would identify you, specific consent will be sought from you.

If it is necessary for anyone else to have access to the data, or for the data to be shared more widely (including any transfers outside the European Economic Area), this will be made clear in the Participant Information Sheet that will be provided to you before you agree to participate in the research.

7. How does the University protect the data?

In order to protect your rights and freedoms when using your personal information for research and to process special category (sensitive) information, the University must have safeguards in place to help protect that data. The University takes the security of your personal data very seriously and it has policies, procedures, training, technical and organisational measures in place to ensure that your information is protected. All research projects or studies involving personal data that has been identified/deemed higher risk are scrutinised and approved by a research ethics panel or committee.

8. How long is my data kept?

If you take part in a research project, you will be provided with a Participant Information Sheet that will outline in more detail how long the data will be held for and, where applicable, the re-use of the data.

9. Data Subject's Rights

Under Data Protection legislation you have the following rights:

- to request access to, and copies of, the personal data that we hold about you;
- to request that we cease processing your personal data;
- to request that we do not send you any marketing communications;
- to request us to correct the personal data we hold about you if it is incorrect;
- to request that we erase your personal data;
- to request that we restrict our data processing activities (and, where our processing is based on

- your consent, you may withdraw that consent, without affecting the lawfulness of our processing based on consent before its withdrawal);
- to receive from us the personal data you have provided to us, in a reasonable format specified by you, to another data controller;
- to object, on grounds relating to your particular situation, to any of our particular processing activities where you feel this has a disproportionate impact on your rights and freedoms.

It is important to understand that the extent to which these rights apply to research will vary and that in some circumstances a right may be limited when the data is being used for research purposes. It should also be noted that we can only implement your rights during the period upon which we hold personal identifiable information about you. Once the information has been irreversibly de-identified or anonymised and becomes part of the research data set, it will not be possible to access your personal information.

If you would like to exercise any of these rights or have any questions regarding your rights, please contact the University's Data Protection Officer, using the contact details under Section 10 below.

10. How to raise a query, concern or complaint

If you have questions about the particular research study you are participating in, please use any contact details you have already been supplied with regarding the research study or project.

If you have general queries, concerns or wish to raise a complaint about how your personal data is used by the University, or if you wish to exercise any of your rights, you should contact the Data Protection Officer in the first instance, using the contact details under Section 2 above.

If you remain dissatisfied, then you have the right to refer the matter to the Information Commissioner's Office (ICO). The ICO can be contacted at:

Information Commissioner's Office,

Wycliffe House, Water Lane,

Wilmslow, Cheshire,

SK9 5AF

Telephone: 0303 123 1113

Website: www.ico.org.uk

8.11 Appendix 11 - Participant's Debrief sheet (oNST)

Debrief Information Sheet

UNIVERSITY OF GLOUCESTERSHIRE

Study Title: Creating a novel lower-limb screening tool for use by grassroots coaches of female adolescent footballers – an online continued professional development session.

Date: February 2024

Dear participant

thank you for taking the time to complete the online neuromuscular screening tool CPD session! I hope you found it informative and useful. By taking part in, and providing answers during the session, the research team will be able to make recommendations on how to successfully implement neuromuscular screening within the volunteer grassroots sporting industry.

This online screening tool session can be supplemented by a face-to-face coaching session. If you wish to take part in such, please email [redacted] If you have provided an email address or contact information to take part in the face-to-face session, please be assure that this information is stored securely and will only be used for the purposes outlined above. You do not have to attend a face-to-face session if you choose not to. You may also email [redacted] and ask for your contact details to be removed at any point.

As the answers that you have provided during the online CPD session are anonymous, the researchers will be unable to specifically delete or redact your specific answers, and they may be used during data analysis. However, please be assured that as all the data is anonymous, no personal information will appear in any subsequent analysis.

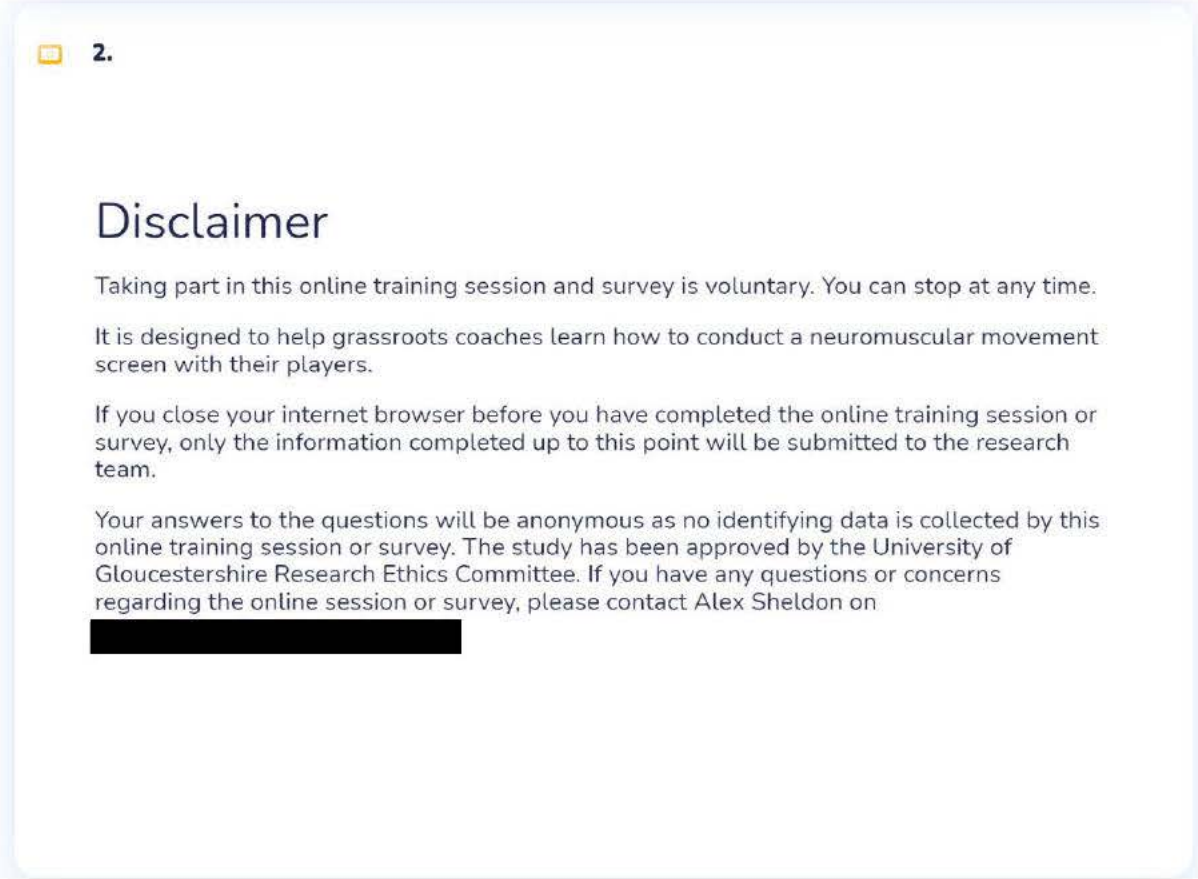
This study forms part of a Professional Doctorate in Sport and Exercise in the School of Sport and Exercise at the University of Gloucestershire. Ethical approval has been granted by the University's ethics board. No external funding has been obtained for this research project. If you have any concerns regarding the ethics of this study or otherwise, please contact;

- Alex Sheldon [redacted] – Lead researcher and Professional Doctorate candidate
- Prof Mark De Ste Croix [redacted] – Project supervisor
- Dr Emily Ryall [redacted] - University REC Chair

Kind regards

Alex Sheldon
Professional Doctorate candidate: School of Sport and Exercise
University of Gloucestershire
Oxstalls Campus, Gloucester, GL2 9HW
[redacted]

8.12 Appendix 12 - Disclaimer and Implied consent slide within oNST



3.

Consent

Before deciding whether or not to take part in this study, it is important that you agree with the following statements:

1 - I understand why this survey is being conducted.

2 - I understand I am able to withdraw from the study by closing my internet browser, but that questions already answered may be used in data analysis.

3 - I understand all data will be completely anonymous.

4 - I understand that I may voluntarily provide my e-mail address which can be used to contact me to ask about taking part in subsequent studies in this project (face-to-face coaching sessions). I also understand that the email address I provide will only be used for such purposes and that I can withdraw my offer to take part in subsequent studies at any time, at which point, my email address will be deleted.

5 - I have access to read the University of Gloucestershire Research Ethics Handbook of Principles and Procedures.

If you have any questions, please email alex.sheldon@connect.glos.ac.uk

Scan the QR code on the left to access the full Infomration and Cosent form

8.13 Appendix 13 – inNST session plan

Face-to-face NST session

Session details	Date:	Time:	Location:
Participant details	Number:		
Equipment	• Tape measure x3, Cones, Rope / marker, Help sheets, QR code printout for Wooclap, Wooclap poll for in-session questions, QR code printout for session feedback survey, Printed session feedback survey,		

Component	Timing	Description/activity	Equipment /	Learning focus
Warm-up	0-10 mins	In groups, **participant (coach)-led** warm-up. Participant coaches to deliver the warm-up as they would with their players, but without the football ball-work component Get coaches to write down current knowledge/confidence etc of NST 1-10 on Wooclap etc	• Wooclap for in-session questions • X6 QR code for Wooclap • X6 QR code for Jisc Online Surveys • Online Surveys Print outs of above as backup	
Screens	10-80 mins	**Round robin of screens**	• Tape measure x3 • Cones • Rope / marker	Wooclap questions link to

		• Using help sheets, in groups, coaches work round each screen station in turn. • Each coach tries running and scoring the screen. Other coaches score the same screen and coaches compare scores • Coaches should try and justify score (i.e. what exactly did they see to score the screen as they did) • After 10 mins, ask coaches to complete Wooclap questions for that screen Extension activity • Film screens on phone, review in slow motion to analyse motion. Did coaches see something on the video they missed live?	• Help sheets • X6 QR code for Wooclap • Wooclap for in-session questions	• Barriers to implementation of this screen • How could you implement this in your club? • What more knowledge do you need?
Cool-down, discussion and signposting	80-90 mins	• **Coach led**-cool down • **Coach-led** group discussion about barriers and facilitators, and how to implement and maintain the screening process • **Instructor-led** signposting to movement competency protocols	• Wooclap for in-session questions • Session feedback survey (QR code and printed) • Movement competency signposting	Wooclap questions link to • Barriers to implementation of this screen • How could you implement this in your club?

				• How would you explain this to parents? • How would you explain this to players? • What more knowledge do you need?
Close				

YouTube links for specific exercise prescriptions

Screen	**Exercise prescription if positive ≤ 13 years old**	**Exercise prescription if positive > 13 years old**
mSEBT (AR component only).	• Single leg stance progression (11+ Kids)	• Single leg stance progression 10.1 • Single leg stance progression 10.2 • Single leg stance progression 10.3
SLHD	• Single legs jump progression (11+ Kids)	• Vertical jump progression 12.1 • Vertical jump progression 12.2 • Vertical jump progression 12.3
mTJA	• Single legs jump progression (11+ Kids)	• Vertical jump progression 12.1

		• Vertical jump progression 12.2 • Vertical jump progression 12.3
	• Spiderman progression	• Sideways Bench Static 8.1 • Sideways Bench Static 8.2 • Sideways Bench Static 8.3

8.14 Appendix 14 – inNST Information and Consent sheets

8.14.1 Participant Information



Study Title: Creating a novel lower-limb screening tool for use by grassroots coaches of female adolescent footballers – an in-person continued professional development session.

Dear potential participant

You are being invited to take part in a research study that is seeking to investigate the usefulness of an in-person continued professional development (CPD) tool that could be used by grassroots coaches of female adolescent footballers.

What is the Purpose of the study?

We are looking to see if completing the in-person session will enhance your knowledge, perceptions and confidence levels in conducting a neuromuscular screening tool with your players. We want to assess any barriers you have in completing the in-person CPD session itself, and explore any facilitators which may mitigate these barriers. We are also looking to see if you believe that the screening tool you learn about during the online CPD session could be rolled out within your club, what will help this roll out and what will hinder it.

What is a neuromuscular screening tool (NST)?

A neuromuscular screening tool is an assessment of movement against a set criteria. This movement will allow assessors to pinpoint if the participant is performing movement in a dysfunctional manner.

What is the in-person session?

The in-person session forms part of a longer CPD product (alongside the online CPD session). The session will last approximately 90 mins. It will take place at a mutually convenient location, ideally where you as a coach, normally coach you players. The session will not be that physically demanding. You will be required to undertake some jumping and lunging activities for a short period of time (i.e. less than 30 seconds on each attempt). Please only take part in the physical aspects of the session if you feel physically able to do so. Please speak to the session leader if you have any questions or concerns.

Why have I been invited to participate?

You will have been asked to take part after voluntarily providing your e-mail address drawing the completion of the online CPD session. You may have also been asked to participate by other coaches at your club who have been involved in developing this session to make sure that it is tailored to the needs of volunteer grassroots

football coaches. The study forms part of a Professional Doctorate research project at the University of Gloucestershire.

Do I have to take part?

No. You have the right not to take part in the in-person CPD session. Furthermore, you have the right to withdraw your participation from this study prior to submission of data. Please note however, that as the data collected throughout the in-person CPD session is anonymised, the researchers will not be able to specifically erase your data.

What are the possible benefits of taking part?

The data gathered from this pilot will allow the research team to make future recommendations regarding the use of the in-person CPD session as a novel lower-limb screening tool for use by grassroots coaches of female adolescent footballers. Furthermore, it will allow researchers to suggest recommendations for hybrid CPD use within the voluntary coaching sector.

How will you collect the data and what happens to the information/results collected in the project?

The data collection aspects of the in-person CPD session are hosted by Wooclap and Jisc Online Survey. The Wooclap tool will be used to gather your input during the session itself. Wooclap is an interactive tool, like a PowerPoint.

Upon completion of the in-person session, you will be asked to answer a variety of questions about 1) your demographic (i.e. age, coaching history etc.), 2) your perceptions and confidence levels, 3) answers to specific questions (i.e. to see if you can score the screens correctly). This will be conducted on Jisc Online Surveys (as it has better functionality for filtering questions based upon your answers to previous questions).

At no point during the completion of the Wooclap or Jisc Online Surveys activities will you be required to enter any personal identifiable details. The anonymised results will form part of a Professional Doctorate thesis. Additionally, the anonymised data may form part of publications written for professional or academic literature.

What happens if I do not want to take part in the project?

Participation is completely voluntary, and no details will be recorded for monitoring purposes. You are free to withdraw at any time or decline from any further participation. If you no longer wish to participate or have any questions, please contact [redacted]

What happens if I do want to take part?

- You will be required to attend the in person session at a time, date and location to be mutually determined between yourself organisers within your club, and the research team.

- You will be required to wear appropriate clothing for the event which would include sporting attire, and appropriate footwear for the location (trainers, astro boots etc).

What happens if I want to withdraw after I have already given consent?

For both the Wooclap and Jisc Online Surveys, you can close the web browser down at any point to withdraw from this study. However, your data collected up to this point may still be used in analysis. As the data is anonymised, no personal data will be received by the research team.

If you wish to withdraw from the in-person session itself, please info the session leader that you are leaving the session.

Ethical Approval and funding

This study forms part of a Professional Doctorate in Sport and Exercise in the School of Sport and Exercise at the University of Gloucestershire. Ethical approval has been granted by the University's ethics board. No external funding has been obtained for this research project. If you have any concerns regarding the ethics of this study or otherwise, please contact the University REC Chair, Dr Emily Ryall, eryall@glos.ac.uk .

Kind regards

Alex Sheldon
Professional Doctorate candidate: School of Sport and Exercise
University of Gloucestershire
Oxstalls Campus, Gloucester, GL2 9HW
[redacted]

8.14.2 Consent

Before deciding whether or not to take part in this study, it is important that you agree with the following statements:

1. I have read the Information sheet (above) and I understand why this project is being conducted.

2. I understand that I am able to withdraw from this study at any time, without having to give a reason.

3. I understand all data will be completely anonymous.

4. I have access to read the University of Gloucestershire Research Ethics Handbook of Principles and Procedures.

YES - I have read the information on this page and have access and have read the Information and Consent sheet (above).

I acknowledge that I have the opportunity to ask any further questions about the project by using the following email – [redacted]

Name_____

Signature_____

Date_____

8.15 Appendix 15 – inNST Physical Activity Readiness Questionnaire

Physical Activity Readiness Questionnaire - PAR-Q (Revised - July 2007)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly : Check YES or NO.

YES	NO	
☐	☐	Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
☐	☐	Do you feel pain in your chest when you do physical activity?
☐	☐	In the past month, have you had chest pain when you were not doing physical activity?
☐	☐	Do you lose your balance because of dizziness or do you ever lose consciousness?
☐	☐	Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?
☐	☐	Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
☐	☐	Do you know of any other reason why you should not do physical activity?

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want - as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can :

- start becoming much more physically active - begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal - this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

➔

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever - wait until you feel better; or
- if you are or may be pregnant - talk to your doctor before you start becoming more active.

Please note: If your health changes so that you then answer "YES" to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

Signature:_____ Identity Document No.:_____

Name:_____ Date:_____

Signature of Parent or Guardian:_____ Witness:_____
(for participants under the age of majority)

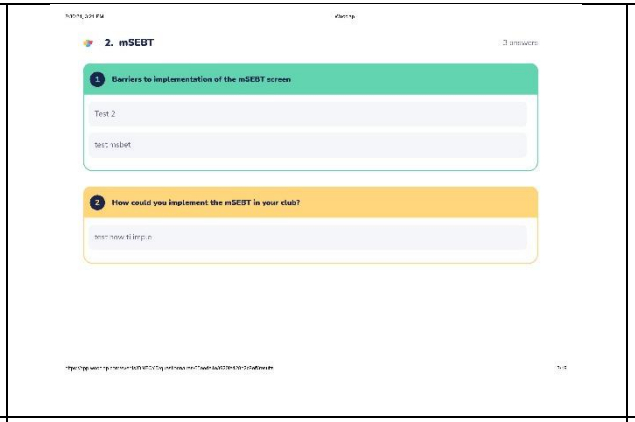
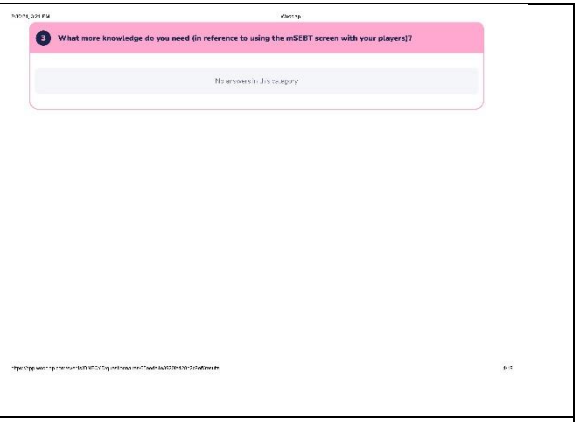
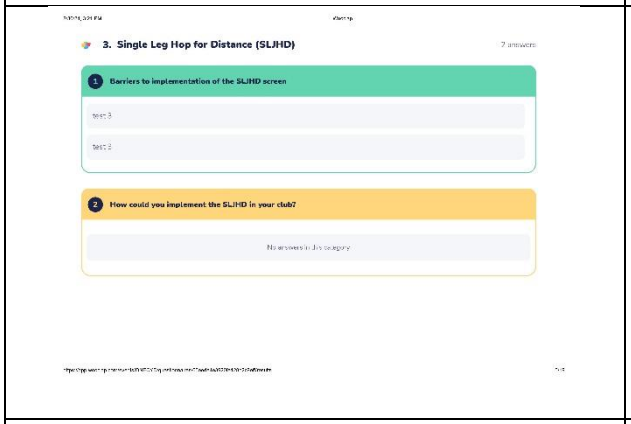
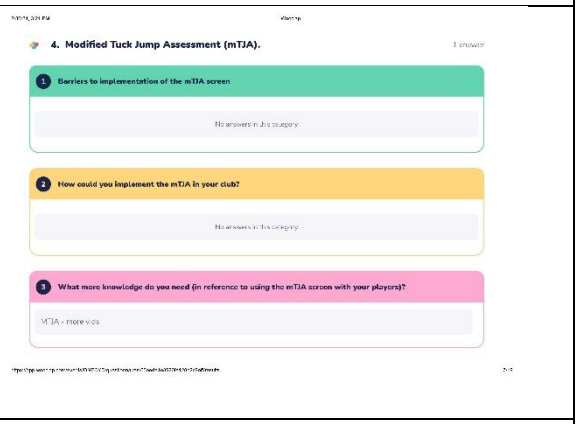
Note: 1.The information provided on this form will only be used for the application for use of Leisure and Cultural Services Department's Fitness Rooms and enrolment of recreation and sports activities. For correction of or access to personal data collected by means of this form, please contact staff of the enrollment counter/district.

2.If you answer "yes" to one or more questions in the "PAR-Q & YOU", your physical condition may not be suitable for taking part in the activity concerned. For safety's sake, you should consult a doctor in advance and produce a medical certificate upon enrolment or hire of fitness equipment to prove that you are physically fit for taking part in the activity. If you fail to produce a medical certificate, you must submit the completed Declaration upon enrolment or hire of fitness equipment.

This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

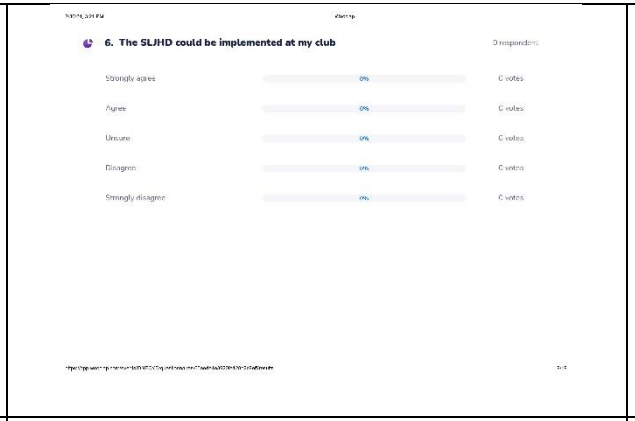
©Canadian Society for Exercise Physiology Supported by: Health Canada

8.16 Appendix 16 - Wooclap screenshots of inNST collaboration section

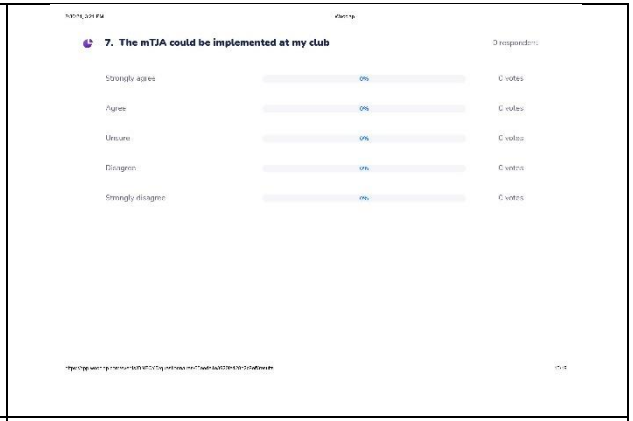
		
1	2	3
		
4	5	6


5. The mSEBT could be implemented at my club
0 respondents
Strongly agree
0%
0 votes
Agree
0%
0 votes
Unsure
0%
0 votes
Disagree
0%
0 votes
Strongly disagree
0%
0 votes

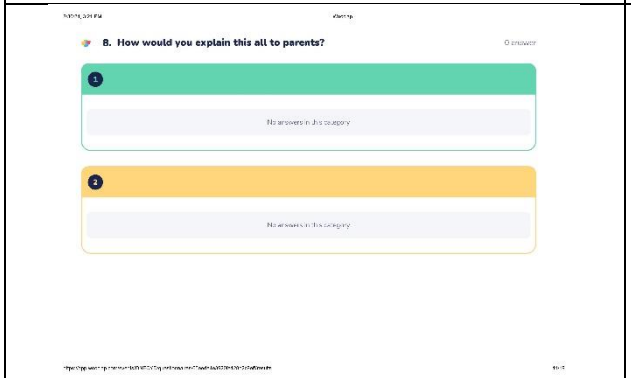
7


6. The SLJHD could be implemented at my club
0 respondents
Strongly agree
0%
0 votes
Agree
0%
0 votes
Unsure
0%
0 votes
Disagree
0%
0 votes
Strongly disagree
0%
0 votes

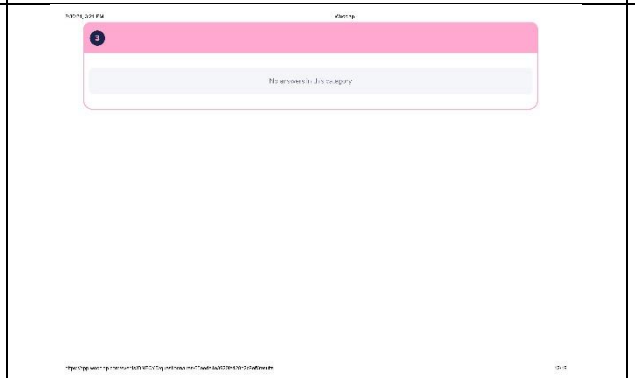
8


7. The mTJA could be implemented at my club
0 respondents
Strongly agree
0%
0 votes
Agree
0%
0 votes
Unsure
0%
0 votes
Disagree
0%
0 votes
Strongly disagree
0%
0 votes

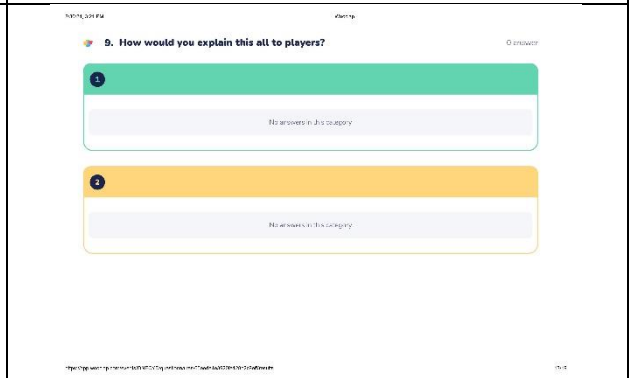
9


8. How would you explain this all to parents?
0 answer
1
No answers in this category
2
No answers in this category

10


3
No answers in this category

11


9. How would you explain this all to players?
0 answer
1
No answers in this category
2
No answers in this category

12



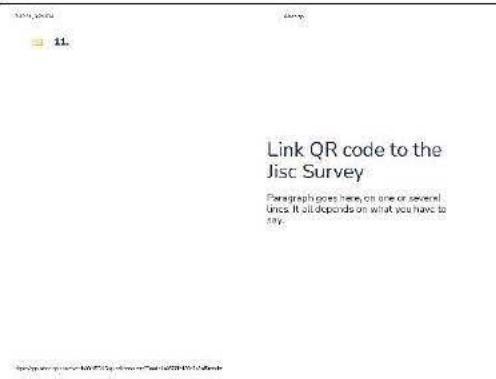
13


10. How would you maintain the use of NST in your club?

14



15

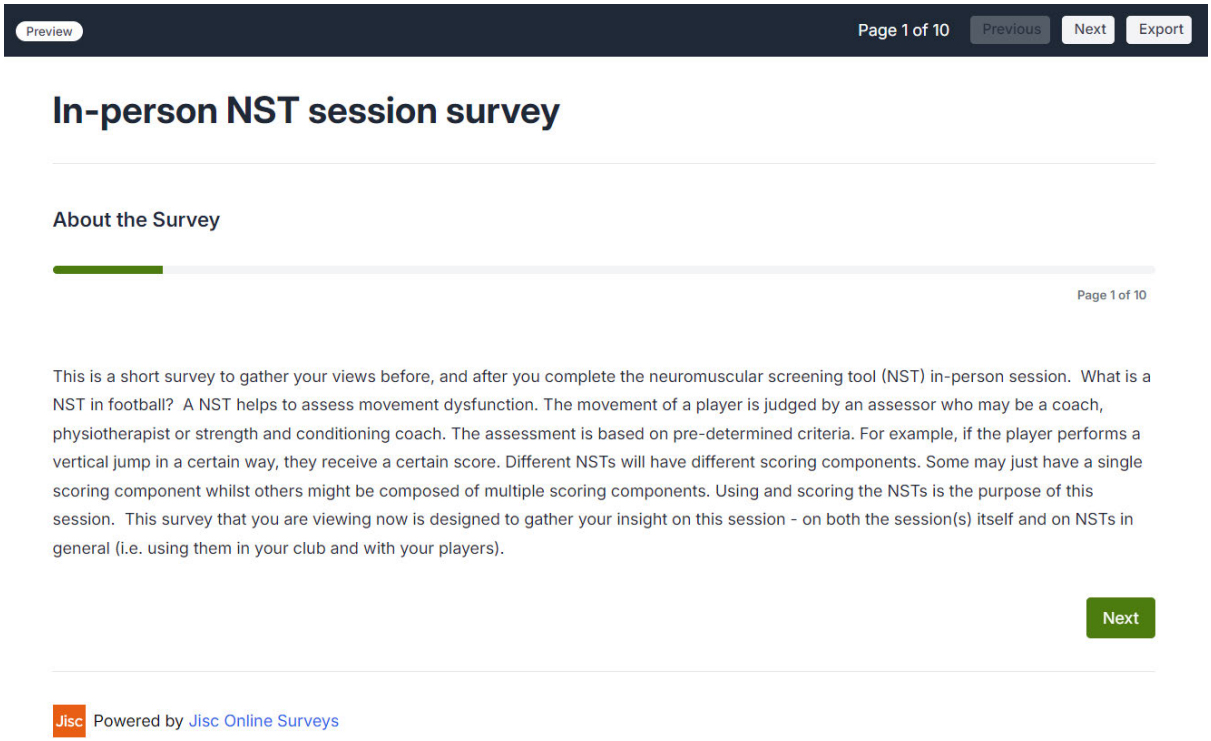

11.
Link QR code to the Jisc Survey
Paragraph goes here, on one or several lines. It all depends on what you have to say.

16

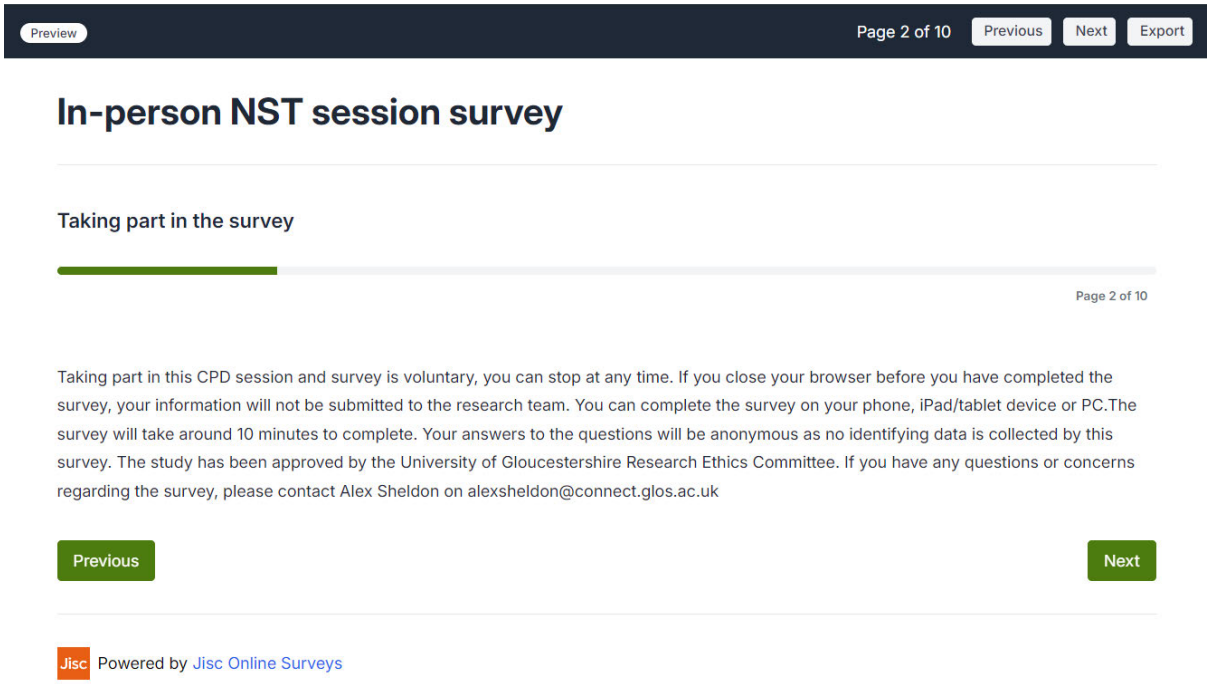

12.
FIFA 11+ booklet??
Scan the QR code to get a PDF of the FIFA 11+ Kids (its chunky, but has everything you need... or use the YouTube!)

17

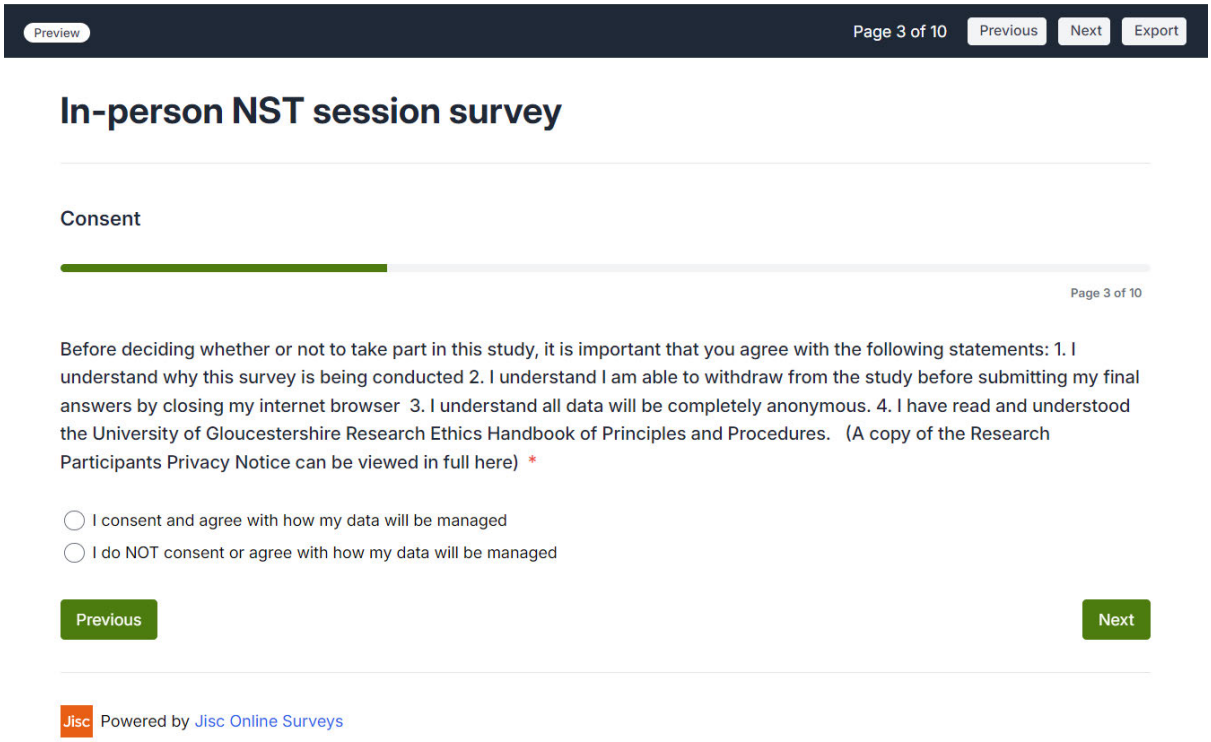
8.17 Appendix 17 – Jisc pre/post inNST survey



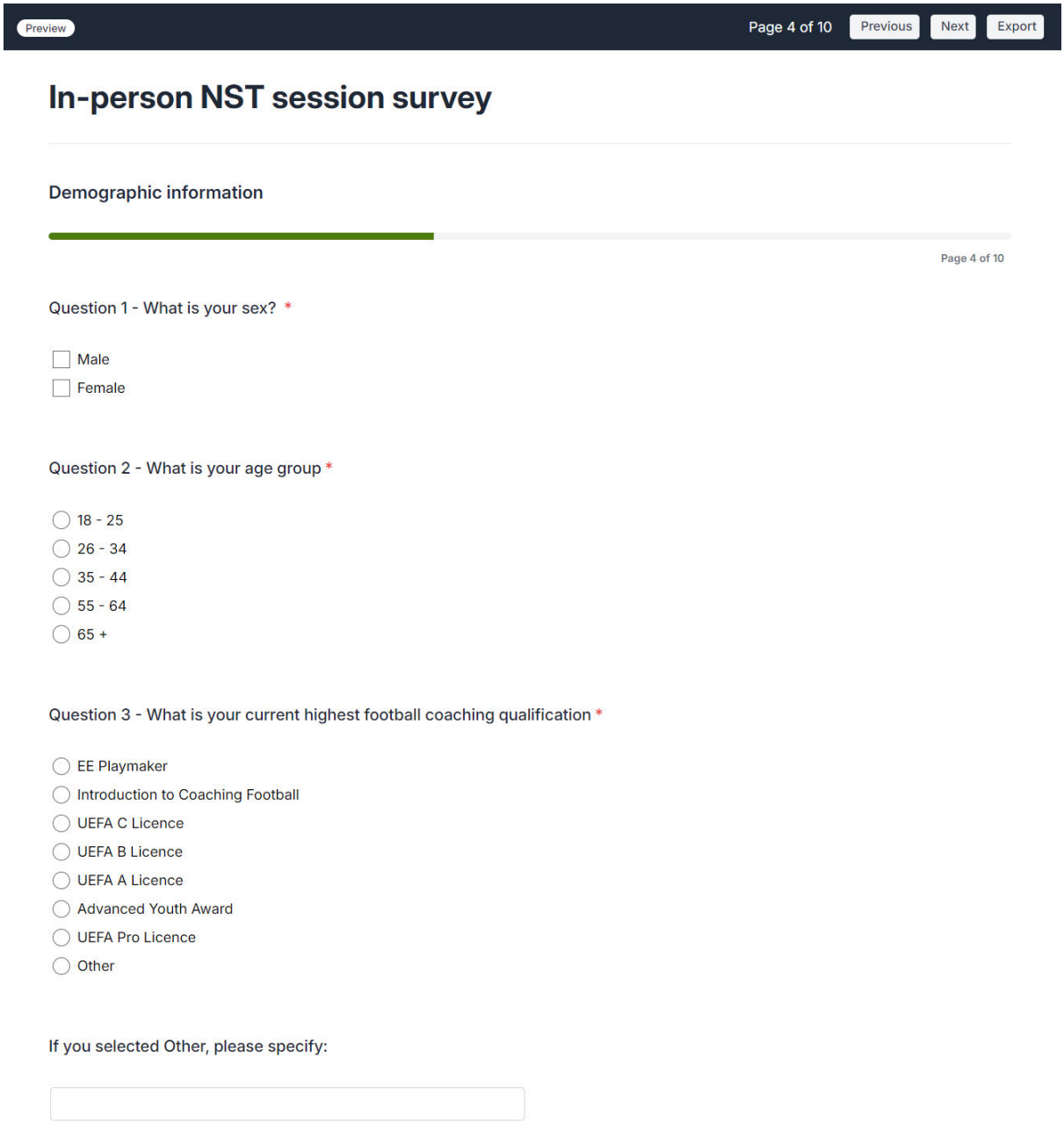
Page 1 of the inNST survey – About the survey



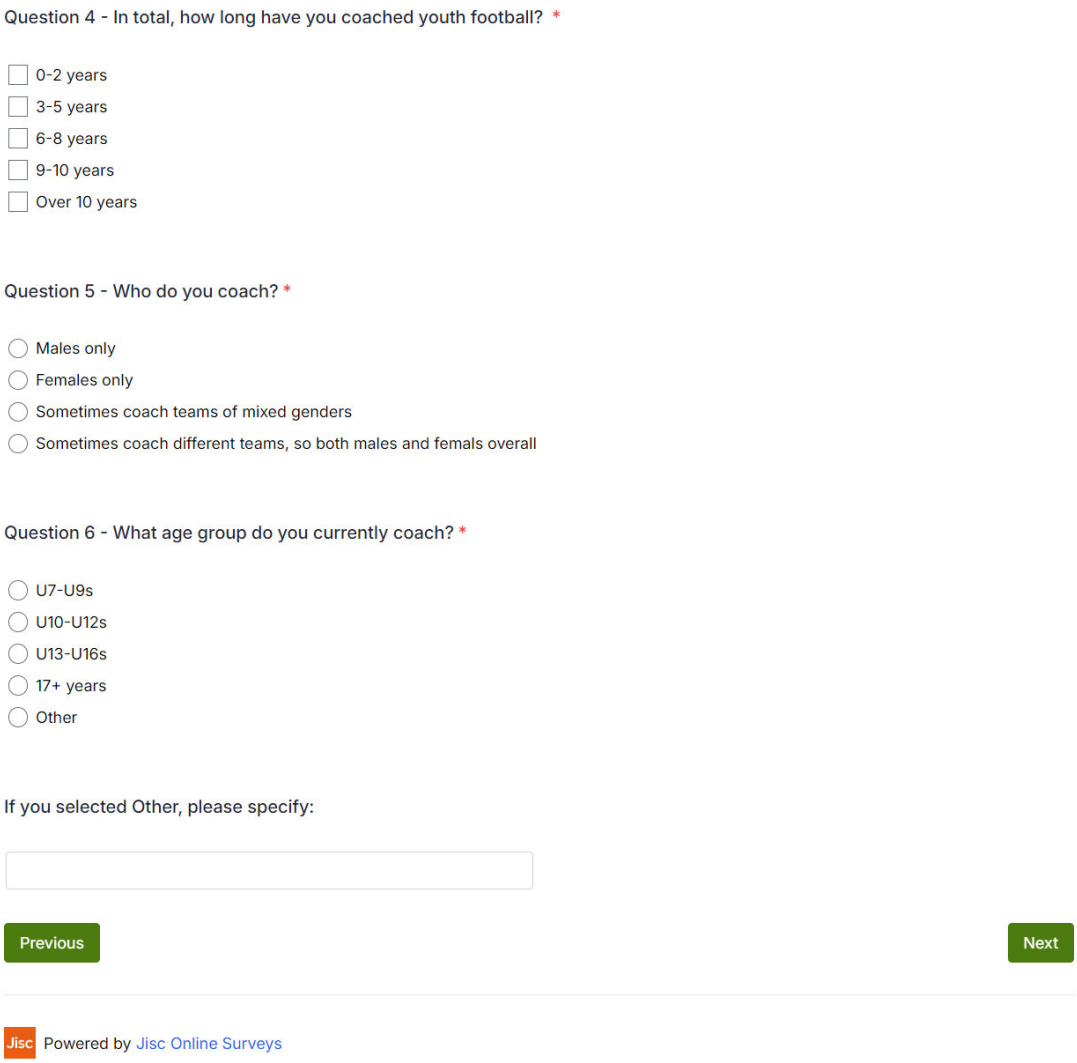
Page 2 of the inNST survey – About the survey – Participant information and signposting



Page 3 of the inNST survey – Participant consent



Page 4(a) of the inNST survey – participant demographics (completed prior to inNST CPD Session)


Question 4 - In total, how long have you coached youth football? *

- [ ] 0-2 years
- [ ] 3-5 years
- [ ] 6-8 years
- [ ] 9-10 years
- [ ] Over 10 years

Question 5 - Who do you coach? *

- ◯ Males only
- ◯ Females only
- ◯ Sometimes coach teams of mixed genders
- ◯ Sometimes coach different teams, so both males and femals overall

Question 6 - What age group do you currently coach? *

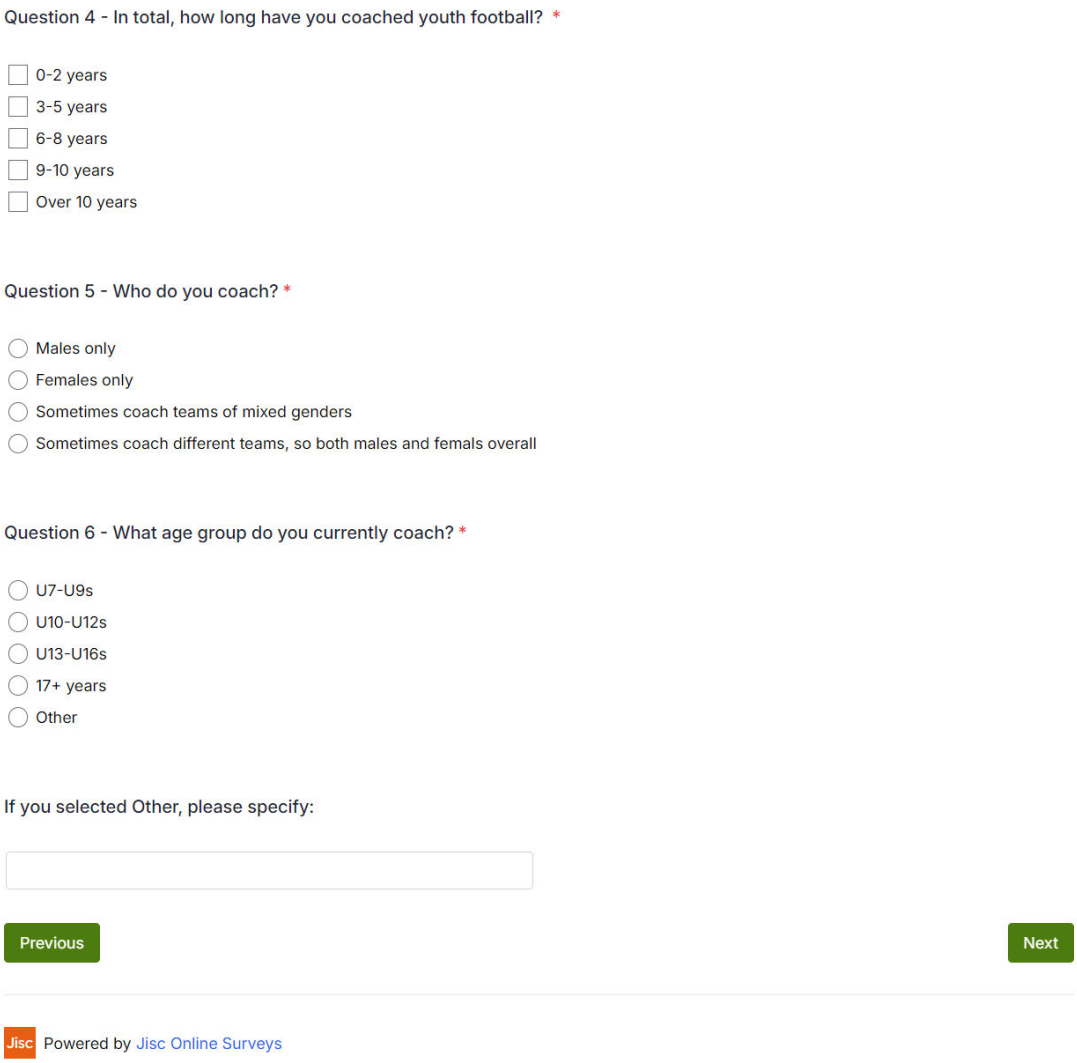
- ◯ U7-U9s
- ◯ U10-U12s
- ◯ U13-U16s
- ◯ 17+ years
- ◯ Other

If you selected Other, please specify:

Previous Next

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Page 4(b) of the inNST survey – participant demographics (completed prior to inNST CPD Session)


Question 4 - In total, how long have you coached youth football? *

- [ ] 0-2 years
- [ ] 3-5 years
- [ ] 6-8 years
- [ ] 9-10 years
- [ ] Over 10 years

Question 5 - Who do you coach? *

- ◯ Males only
- ◯ Females only
- ◯ Sometimes coach teams of mixed genders
- ◯ Sometimes coach different teams, so both males and femals overall

Question 6 - What age group do you currently coach? *

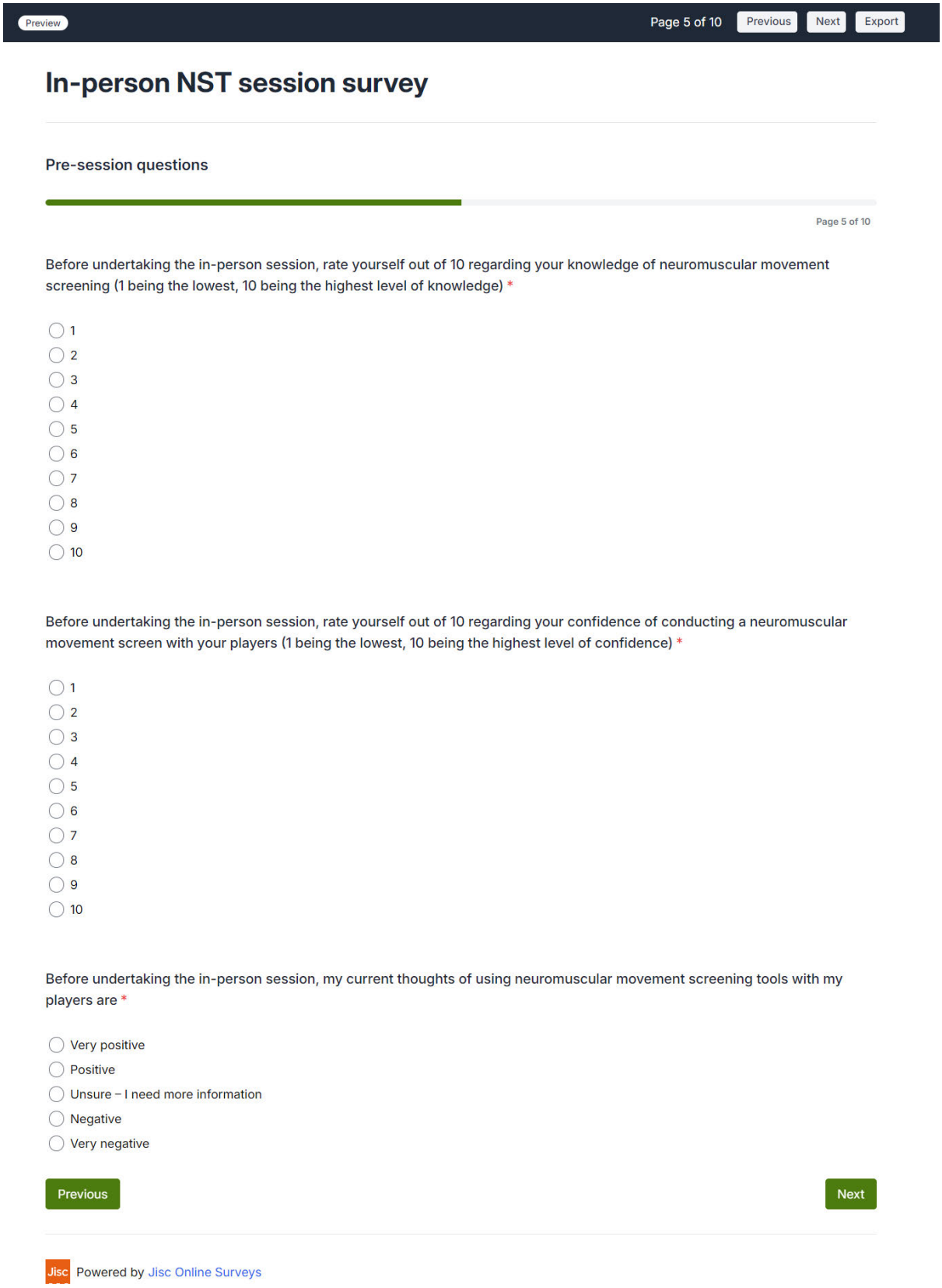
- ◯ U7-U9s
- ◯ U10-U12s
- ◯ U13-U16s
- ◯ 17+ years
- ◯ Other

If you selected Other, please specify:

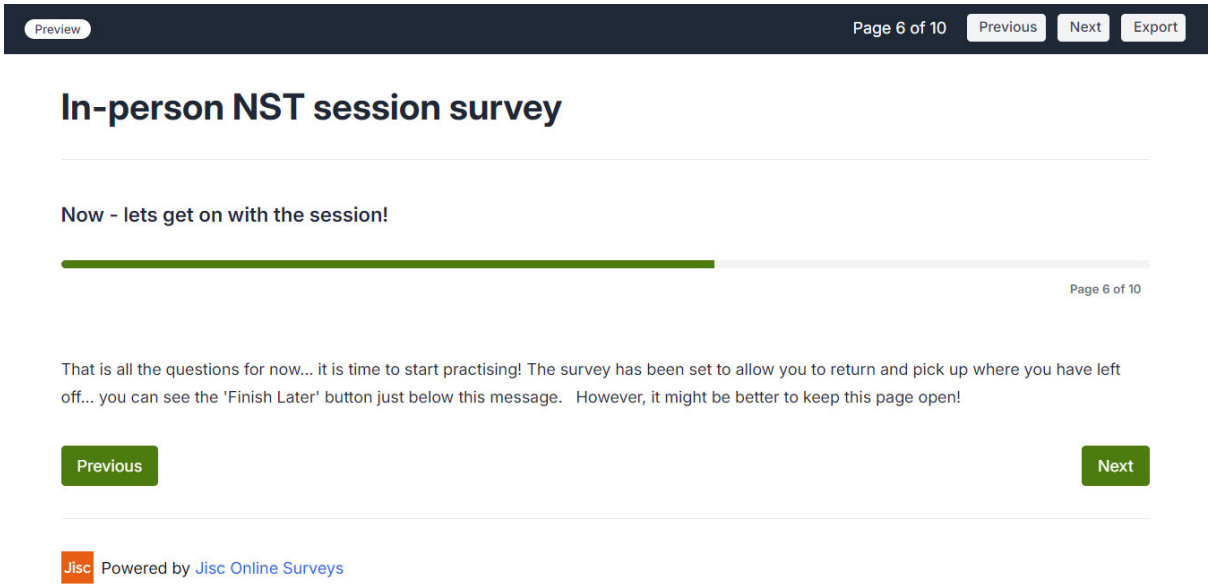
Previous Next

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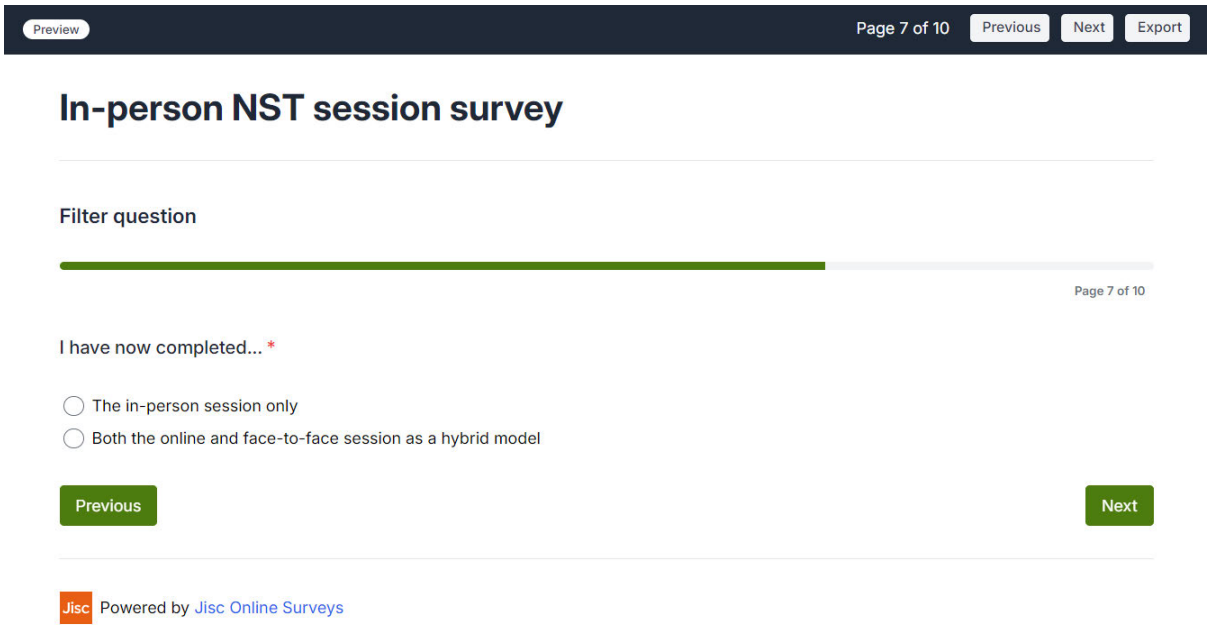
Page 4(b) of the inNST survey – participant demographics (completed prior to inNST CPD Session)



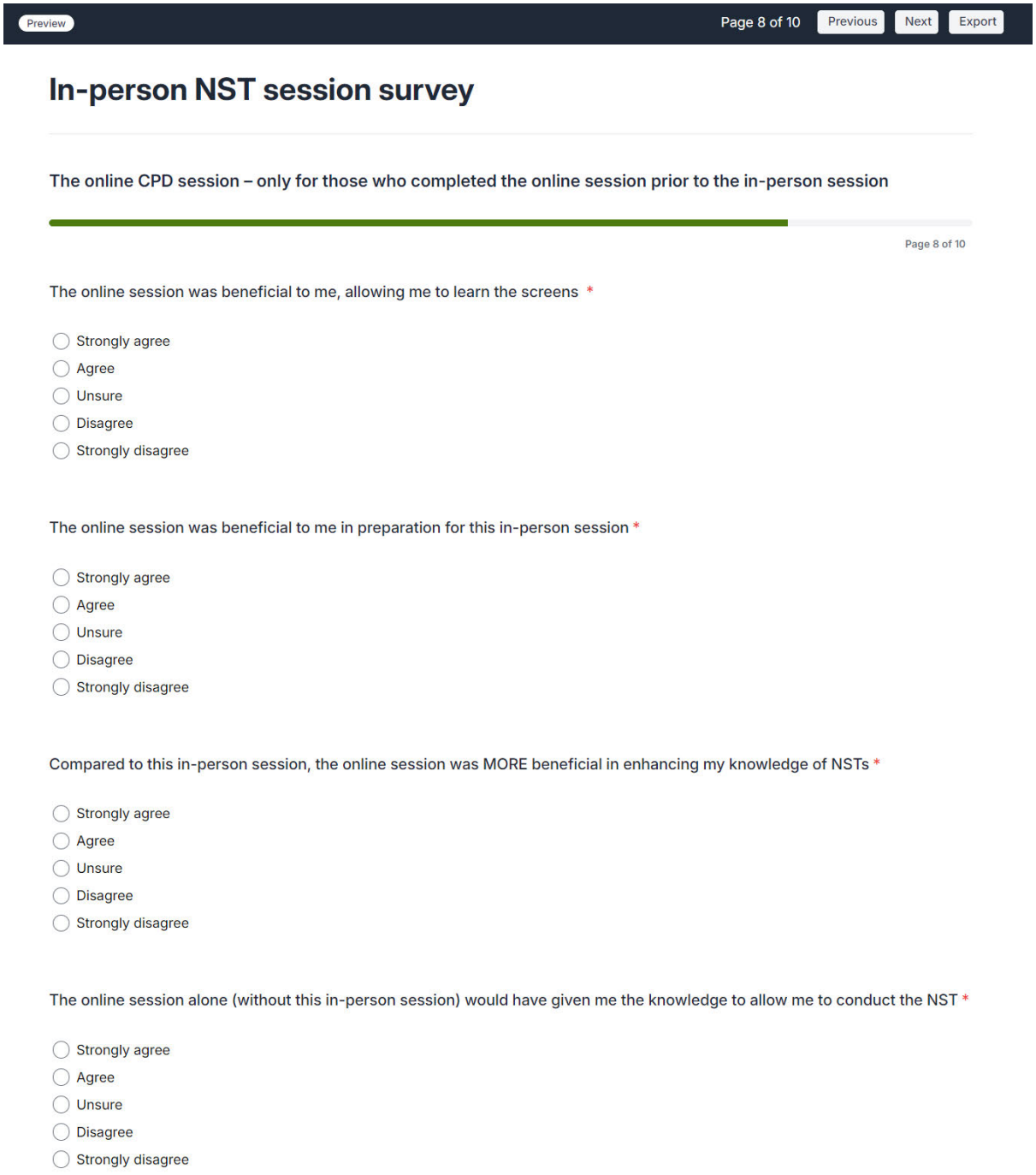
Page 5 of the inNST survey – Knowledge and confidence of NSTs (completed prior to inNST CPD Session)



Page 6 – Signposting for participant to pause completing the survey and take part in the main inNST CPD session



Page 7 – Filter question to filter participants to questions based upon prior completion of the oNST



Page 8(a) – Views on oNST compared to inNST – Only completed by participants who have attended both the oNST and inNST

The online session alone (without this in-person session) would have given me the confidence to allow me to conduct the NST *

- ◯ Strongly agree
- ◯ Agree
- ◯ Unsure
- ◯ Disagree
- ◯ Strongly disagree

The online session should remain as part of the overall training product (coupled with the in-person session) *

- ◯ Strongly agree
- ◯ Agree
- ◯ Unsure
- ◯ Disagree
- ◯ Strongly disagree

Which session, online or in-person improved your knowledge of NSTs the most? *

- ◯ Online CPD session
- ◯ In-person CPD session

Which session, online or in-person improved your confidence of NSTs the most? *

- ◯ Online CPD session
- ◯ In-person CPD session

Given the option again, which session(s) would you attend? *

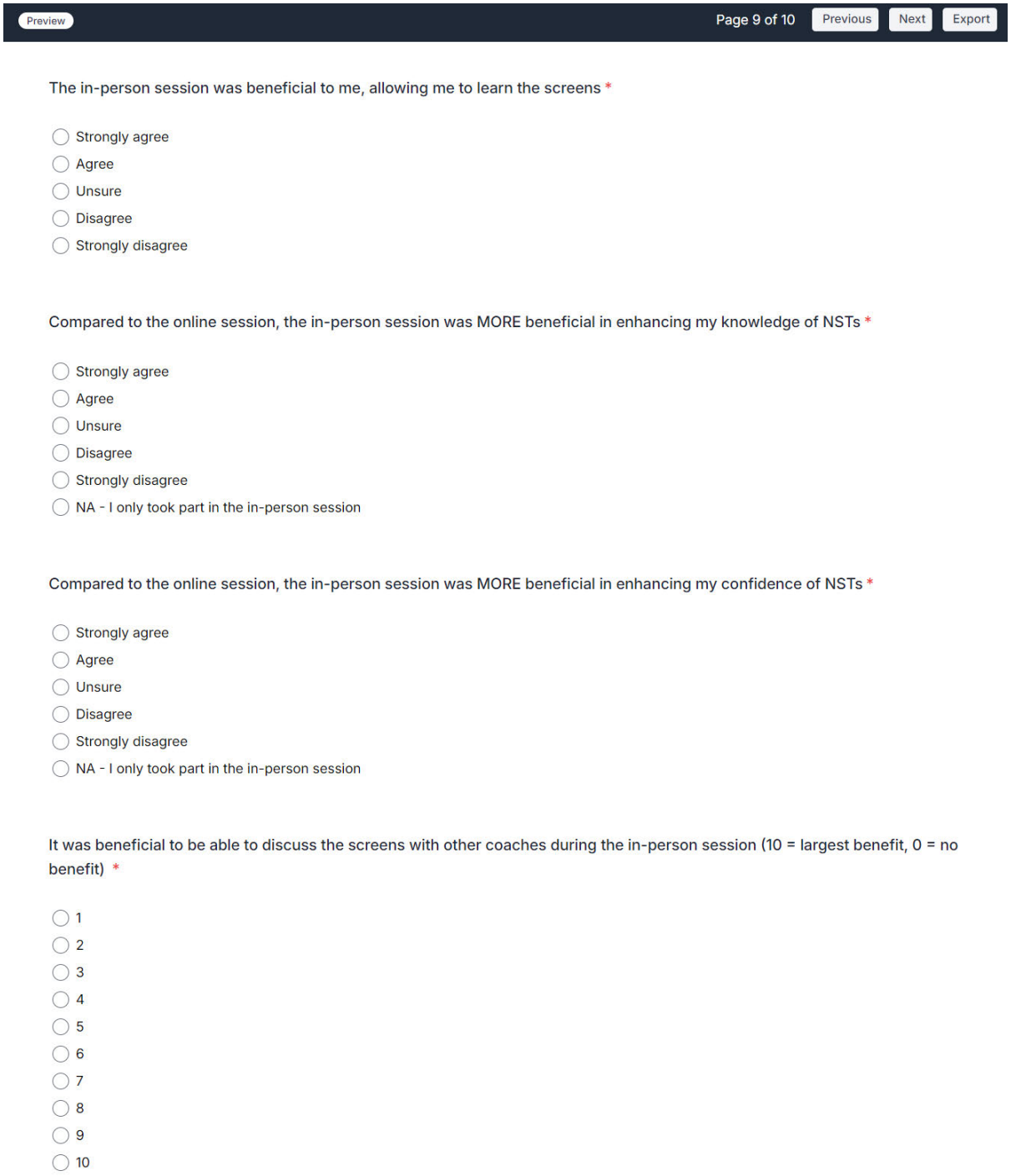
- ◯ Yes
- ◯ No

Why did you give the answer you did?

How could the online session be improved, making it more relevant to coaches for grassroots female footballers? *

Previous Next

Page 8(b) – Views on oNST compared to inNST – Only completed by participants who have attended both the oNST and inNST



Page 9(a) – Views on inNST post CPD session compared– Completed by all participants

It was beneficial to be able to discuss with other coaches how we could implement the NST within our clubs (10 = largest benefit, 0 = no benefit) *

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10

This in-person session alone (without the online session) would give me the knowledge to allow me to conduct the NST *

- ◯ Strongly agree
- ◯ Agree
- ◯ Unsure
- ◯ Disagree
- ◯ Strongly disagree

This in-person session alone (without the online session) would give me the confidence to allow me to conduct the NST *

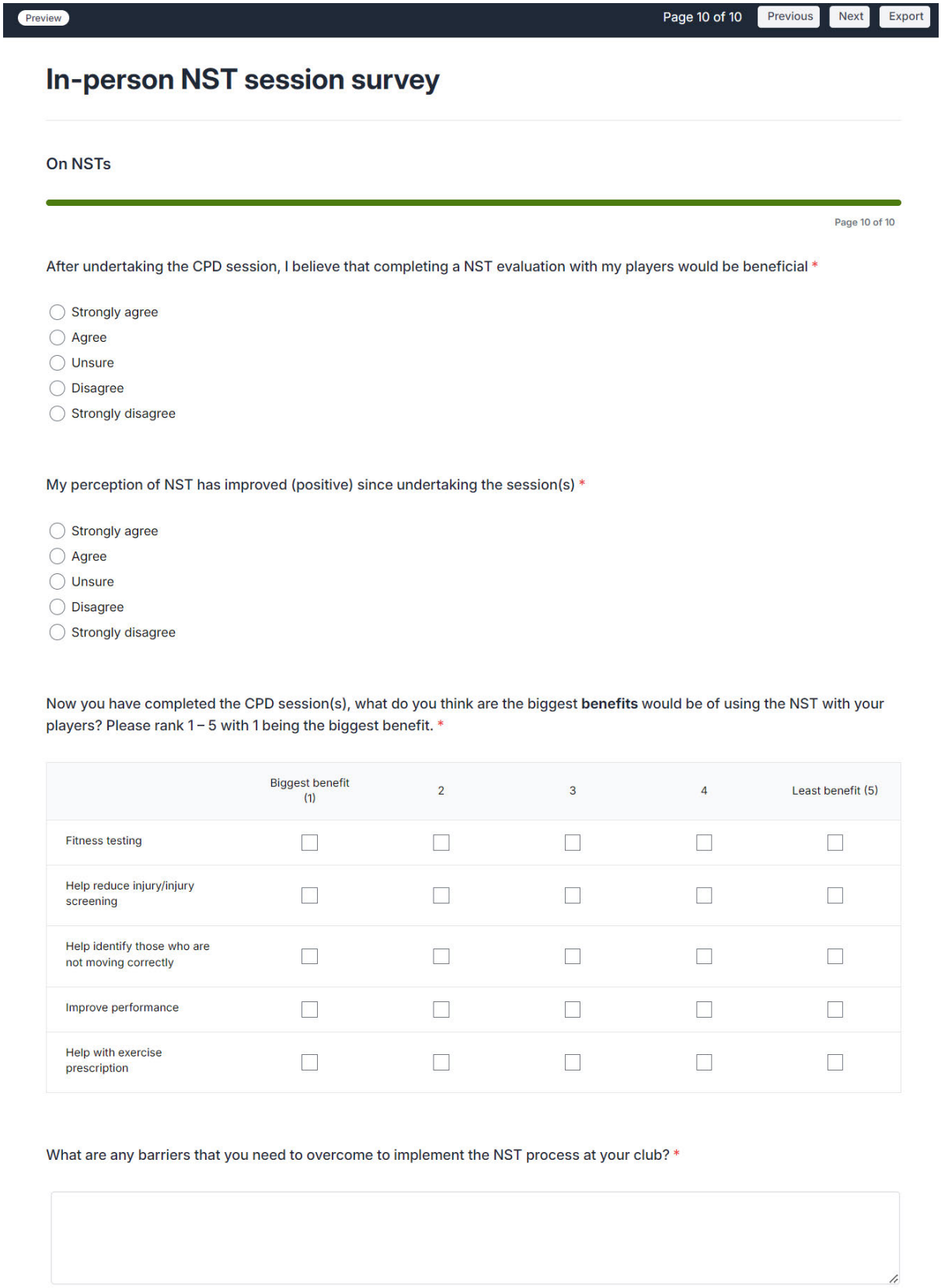
- ◯ Strongly agree
- ◯ Agree
- ◯ Unsure
- ◯ Disagree
- ◯ Strongly disagree

How could this in-person session be improved, making it more relevant to coaches of grassroots female footballers?

Previous Next

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Page 9(b) – Views on inNST post CPD session compared– Completed by all participants



Page 10(a) of the inNST survey (post inNST CPD session section) - Completed by all participants

What are any barriers that you need to overcome to implement the NST process at your club? *

What are any facilitators needed to implement the NST process at your club? *

As a result of this training, I will be talking to other coaches (who didn't attend the training) about NSTs *

- ◯ Strongly agree
- ◯ Agree
- ◯ Unsure
- ◯ Disagree
- ◯ Strongly disagree

I think the training event (in-person and online if both attended) will be useful for other coaches *

- ◯ Strongly agree
- ◯ Agree
- ◯ Unsure
- ◯ Disagree
- ◯ Strongly disagree

Why did you give the answer you did? *

Page 10(b) of the inNST survey (post inNST CPD session section) - Completed by all participants

I will use the NST in my club *

- ○ Strongly agree
- ○ Agree
- ○ Unsure
- ○ Disagree
- ○ Strongly disagree

I see myself using the NST throughout at least, next season *

- ○ Strongly agree
- ○ Agree
- ○ Unsure
- ○ Disagree
- ○ Strongly disagree

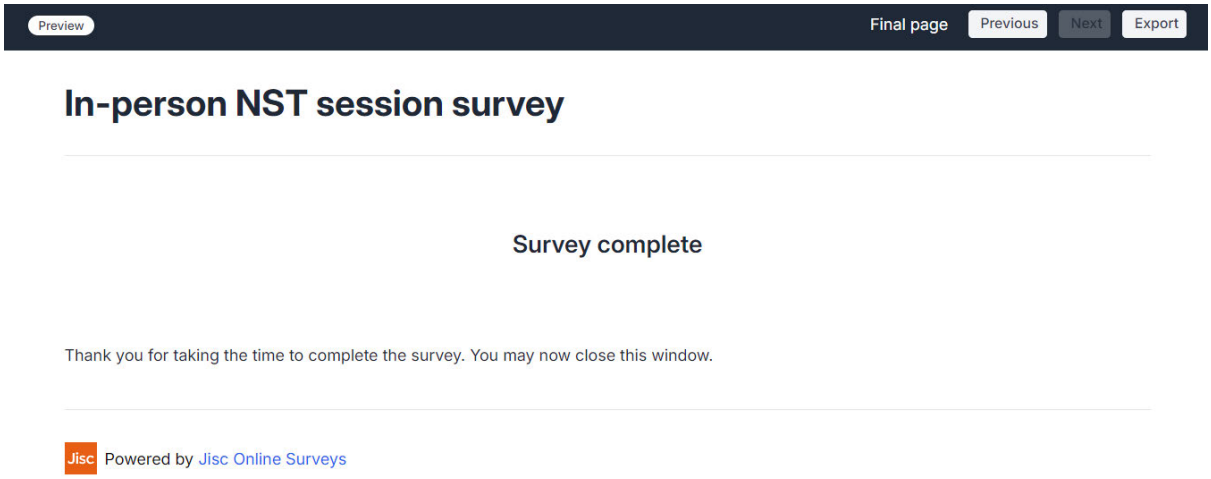
Why did you give the answer you did? *

After being through the training (including in-person and online, if both attended), what advice could you give to encourage the continued, long-term use of the NST by grassroots coaches *

Previous Submit

Jisc Powered by Jisc Online Surveys

Page 10(c) of the inNST survey (post inNST CPD session section) - Completed by all participants



Page 11 – Final page of inNST

8.18 Appendix 18 - Participant's Debrief sheet (inNST)

Debrief Information Sheet

UNIVERSITY OF GLOUCESTERSHIRE

Study Title: Creating a novel lower-limb screening tool for use by grassroots coaches of female adolescent footballers – an in-person continued professional development session.

Date: March 2024

Dear participant

Thank you for taking the time to complete the in-person neuromuscular screening tool CPD session! I hope you found it informative and useful. By taking part in, and providing answers during the session, the research team will be able to make recommendations on how to successfully implement neuromuscular screening within the volunteer grassroots sporting industry.

As the answers that you have provided during the in-person CPD session are anonymous, the researchers will be unable to specifically delete or redact your specific answers, and they may be used during data analysis. However, please be assured that as all the data is anonymous, no personal information will appear in any subsequent analysis. If you would like a copy of the answers your group discussed during your in-person session, please contact [redacted]

This study forms part of a Professional Doctorate in Sport and Exercise in the School of Sport and Exercise at the University of Gloucestershire. Ethical approval has been granted by the University's ethics board. No external funding has been obtained for this research project. If you have any concerns regarding the ethics of this study or otherwise, please contact;

- Alex Sheldon [redacted] – Lead researcher and Professional Doctorate candidate
- Prof Mark De Ste Croix ([redacted] – Project supervisor
- Dr Emily Ryall[redacted] - University REC Chair

Kind regards

Alex Sheldon
Professional Doctorate candidate: School of Sport and Exercise
University of Gloucestershire
Oxstalls Campus, Gloucester, GL2 9HW
[redacted]

8.19 Appendix 19 - SPSS output for Spearman's rank-order correlation

Table 16. SPSS output for Spearman's rank-order correlation

Correlations

			Qu No	Percentage Response
Spearman's rho	Qu No	Correlation Coefficient	1.000	-.938**
		Sig. (2-tailed)	.	<.001
		N	35	35
	Percentage Response	Correlation Coefficient	-.938**	1.000
		Sig. (2-tailed)	<.001	.
		N	35	35

**. Correlation is significant at the 0.01 level (2-tailed).

8.20 Appendix 20 – Question drop-of rate per question on the oNST

Table 17. Question drop-of rate per question on the oNST

	Reponses (n)	Reponses (%)	Question topic
	36	100	
Qu1	29	81	Pre knowledge
Qu2	27	75	Pre confidence
Qu3	25	69	Pre perceptions
Qu4	24	67	Demographic
Qu5	24	67	
Qu6	24	67	
Qu7	24	67	
Qu8	24	67	
Qu9	24	67	
Qu10	22	61	Education section questions (knowledge check)
Qu11	22	61	
Qu12	21	58	
Qu13	21	58	
Qu14	21	58	
Qu15	19	53	
Qu16	19	53	
Qu17	16	44	
Qu18	16	44	
Qu19	16	44	
Qu20	16	44	
Qu21	16	44	
Qu22	16	44	
Qu23	16	44	
Qu24	16	44	
Qu25	16	44	
Qu26	16	44	Post knowledge
Qu27	16	44	Post confidence
Qu28	16	44	Post perceptions
Qu29	16	44	Beneficial with players
Qu30	16	44	Want in-person question
Qu31	16	44	Only for those not wanting inNST
Qu32	16	44	
Qu33	16	44	
Qu34	15	42	
Qu35	15	42	
Qu36	14	39	

8.21 Appendix 21 – Pre and post oNST knowledge and confidence self-reported rankings

Table 18. Pre and post oNST knowledge self-reported rankings

Participant number. No	Knowledge pre oNST	Knowledge post oNST
1	6	8
5	1	4
6	1	5
13	7	5
20	6	9
21	5	8
22	2	5
24	3	6
26	2	5
28	2	5
29	1	5
30	2	4
31	1	8
33	2	7
34	1	7
35	1	6
Mean	**2.69**	**6.06**
	2.02 SD	**1.52 SD**

Table 19. Pre and post oNST confidence self-reported rankings

Participant number. No	Confidence pre oNST	Confidence post oNST
1	6	9
5	1	4
6	1	5
13	7	5
20	6	10
21	5	8
22	2	5
24	3	5
26	3	6
27	1	6
28	2	7
30	2	4
31	1	8
33	1	8
34	1	7
35	1	6
Mean	**2.69**	**6.44**
	2.05 SD	**1.73 SD**

8.22 Appendix 22 - SPSS output for Wilcoxon Signed Ranks Test

8.22.1 Self-perceived knowledge, pre vs post- oNST

Table 20. Related-Samples Wilcoxon Signed Rank Test Summary - Knowledge pre vs post- oNST (SPPS output)

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The median of differences between Knowledge pre oNST and Knowledge post oNST equals 0.	Related-Samples Wilcoxon Signed Rank Test	<.001	Reject the null hypothesis.

a. The significance level is .050.

b. Asymptotic significance is displayed.

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	16
Test Statistic	134.000
Standard Error	19.138
Standardized Test Statistic	3.449
Asymptotic Sig.(2-sided test)	<.001

8.22.2 Self-perceived Confidence, pre vs post- oNST

Table 21. Related-Samples Wilcoxon Signed Rank Test Summary - Confidence pre vs post- oNST (SPPS output)

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The median of differences between Confidence pre oNST and Confidence post oNST equals 0.	Related-Samples Wilcoxon Signed Rank Test	<.001	Reject the null hypothesis.

a. The significance level is .050.

b. Asymptotic significance is displayed.

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	16
Test Statistic	134.000
Standard Error	19.242
Standardized Test Statistic	3.430
Asymptotic Sig.(2-sided test)	<.001

8.22.3 Performance on open versus closed questions based on the percentage of correct answers during oNST

Table 22. Independent-Samples Mann-Whitney U Test of open vs. closed questions on oNST (SPSS output)

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of PercentCorrect is the same across categories of Questiontype.	Independent-Samples Mann-Whitney U Test	.837[c]	Retain the null hypothesis.

a. The significance level is .050.

b. Asymptotic significance is displayed.

c. Exact significance is displayed for this test.

Independent-Samples Mann-Whitney U Test Summary

Total N	16
Mann-Whitney U	33.500
Wilcoxon W	61.500
Test Statistic	33.500
Standard Error	9.342
Standardized Test Statistic	.214
Asymptotic Sig.(2-sided test)	.830
Exact Sig.(2-sided test)	.837