Reduced severity of lumbo-pelvic-hip injuries in professional Rugby Union players following tailored preventative programmes.

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Abstract

Objectives: The aim of this study was to tailor lumbo-pelvic-hip (LPH) injury reduction programmes in professional rugby union players based on screening data and examine its effectiveness.

Design: Prospective case controlled study.

Methods: Twenty-eight professional rugby union players were screened pre- and immediately post- the YO-YO intermittent recovery level 1 test using six hip and groin strength tests (adductor squeeze at 0^{o}, 60^{o} and 90^{o}, prone hip extension, abductor, adductor hand held dynamometry). The changes in hip and groin measures, were analysed using hierarchical cluster analysis. Three clusters emerged and a tailored LPH injury reduction programme was administered for each cluster. In addition, 22 players who were not involved in the initial testing received a generic LPH injury reduction programme and were used as the control. Seasonal information for LPH injury incidence, severity and prevalence were compared to the previous season.

Results: The same number of injuries were observed when the prospective injury surveillance data was compared to the previous season, however a reduced injury severity (936d v 468d), average severity (78 ± 126d v 42 ± 37d) and prevalence (21% v 19%) were found. Moreover, LPH injury severity for players who were prescribed a tailored injury reduction programme (209d) were 50d less than players given a generic LPH injury reduction programme (259d).

Conclusions: Our preliminary observations support the effectiveness of grouping players and tailoring intervention based on common group characteristics in reducing the severity of LPH injuries in professional Rugby Union.

Introduction

The lumbo-pelvic-hip (LPH) complex comprises the lumbar spine, pelvis, hip and groin. LPH injuries, are common in many sports that require rapid acceleration and deceleration, sudden changes of direction and kicking[1, 2, 3, 4]. In Rugby Union, LPH and in particular groin injuries have featured as one of the most frequently cited injuries[5,6]. The incidence of LPH injuries in Rugby Union range between 28.6 to 37.5 per 1000 hours of match play or training[7]. Recently, Fuller et al[8] found a much lower rate of hip and groin injuries at the 2015 Rugby World Cup at 5.8 per 1000 hours suggesting that the standard of competition may have an impact on injury risk, therefore injury reduction is of greater importance to therapists working at club than international level.

The direct consequence of LPH injury is time lost from training and competition. This can be reported as 'severity' defined as the number of days lost from competition and practice[8]. Rugby Union players who sustained LPH injury can expect to lose on average 61 days when the injury occurs during training compared to 83 days[9] when it occurs during competition. Like all injuries sustained the consequences extend beyond time loss and include: significant financial costs (including medical and loss of earning), and may also impact team performance. Furthermore, once injured, the player will be more susceptible to future re-injury or secondary injuries due to compensatory movements or lack of practice and deconditioning[10]. Given the likelihood of a professional rugby union player sustaining a LPH injury, medical teams and coaches search for ways to protect their players by preparing them using conditioning exercises sometimes referred to as 'injury prevention exercises' or 'prehabilitation'. These exercise programmes aim to address inherent physiological risk factors, which may predispose the athlete to subsequent groin injury[10,11]. Low absolute hip adductor strength and hip adductor to abductor ratio may result in decreased muscle capacity, muscle imbalance and an increased risk of groin injury from side stepping, cutting, sudden acceleration or deceleration and change of direction mechanisms [12,13].

While inherent risk factors for LPH injury have been identified, little evidence to support that modifying these risk factors can have positive outcomes and successfully reduce the incidence of LPH injury have been provided. No intervention study involving professional Rugby Union players has been conducted to date. Two of the most prominent studies have involved soccer players, however neither study has shown a significant reduction in groin injury from the use of a generic exercise programmes[13,14]. A one-size fits all approach was adopted and so may explain the lack of positive outcomes following interventions. LPH injuries are complex and multifaceted with a large number of potential pain generating structures[15]. When developing injury prevention programmes of the hip and groin in team sports it is clear that understanding those factors associated with injury risk and regional anatomy should be carefully considered. Moreover, there are various assessments available that the Sports Therapists and Medical Staff can use to screen their players to identify players at risk. The process has been outlined by van Mechelen et al[16.]

In practice, various assessments can be used to screen rather than the laboratory based assessments on an isokinetic dynamometry device, which are not readily available and time consuming. The efficacy of hand held dynamometry (HHD) and squeeze tests have been explored and providing they are performed by a skilled operator they can produce reliable results[17, 18]. HHD adductor squeeze tests have also demonstrated excellent reliability at 0^{o}, 45^{o} and 90^{o} [19]. Given, the complexity of the LPH complex a number of tests may be required to provide greater insight to the condition of the player.

Screening of LPH injury risk in a fatigued state may provide additional information not apparent in a fully rested athlete. Knowledge of the changes in strength measures following exhaustive running may have additional benefits and illuminate underpinning mechanisms that may be masked when players are rested. To date, only one study has examined the change to adductor squeeze at 45^{o} pre and post an academy rugby union match[20]. Their results show trivial changes to adductor scores to 14 academy rugby union players immediately (-1.3% ± 2.5%) and 24hours post-match (-0.7% ± 3%) with small increases at 48hours (+3.8% ± 1.9%) and further reductions at 72hours (- 3.1% ± 2.2). No study at present has, however, examined the effect of broader LPH strength post voluntary exhaustive running.

When the number of tests and the number of players in a squad are considered, the logistics of implementing tailored programs from the information gained from screening are great. To date, we are unaware of any guidelines. From experience it is those players with notable between limb imbalances and previous injuries that are prioritised for specific training. This may explain why LPH injuries continue to be so problematic.

The aim of this study was to report the process of screening athletes, grouping them by their similarities in scores on a battery of hip and groin tests following the Yo-Yo Intermittent Recovery Test (Yo-Yo IR1). A secondary aim of the study was to explore the effectiveness of this tailored injury reduction programme by comparing previous season injury surveillance data and also a group of players who received a ‘one size fits all’ programme. This process may improve practice where logistical constraints such as time, staffing, access to equipment and lack of guidelines impede screening.

Method

Twenty-eight male professional regional rugby union players (age 24.4 ± 3.8 years; stature181.6 ± 6.8 cm; mass 105 ± 13.08 kg) fit and available at the start of the 2015-2016 preseason volunteered to take part in this study (backs n= 11, forwards n=17). Seven players had suffered a time-loss LPH injury in the previous 12 months however all players were currently asymptomatic of LPH pain and in full training. The remainder of the squad (n=22) were excluded by absence at the start of pre season (e.g. international rugby duties at Senior and Under 20s level) or injuries that were unsuitable for testing. All players gave written informed consent to participate in the study, which had been approved by the University of Wales, Trinity Saint David Research Ethics Committee.

In the 2015-16 season the team completed 35 competitive matches per season in the domestic league and European cup competitions. In comparison the team played 34 games across three competitions in the 2014-15 season. GPS data for the 2014-15 and 2015-16 seasons were compared. Average distance covered per week in training and games for forwards and backs, and average meters per min in training and games for forwards and backs were comparable across the two seasons.
(see supplementary table X)

Table 1 shows images of all LPH screening assessments used in this study. Isometric adductor squeeze at 0°, 60° hip flexion and 90/90° hip and knee flexion were tested in supine using a manual sphygmomanometer (Anaeroid sphygmomanometer, Timesco, England) pre-inflated to 10mmHg and placed between the players knees such that the middle third of the cuff was located at the most prominent point of the medial femoral condyles[21]. For 0°, the players were instructed to lie in supine with the hips and knees fully extended. The 60° position was located by bringing the medial malleolus of the right leg in line with the left tibiofemoral joint line. The left leg was then flexed up so that the medial malleoli were aligned and touching. The 90/90° position was located by positioning the patients hips and knees at 90° flexion, measured using a universal goniometer. Once positioned, the player was instructed to squeeze the cuff as hard as he could for 5 seconds. The highest-pressure reading displayed on the sphygmomanometer was recorded during each maximal adductor squeeze. Players were given 1-minute rest in between each adductor squeeze.

TABLE 1: Hand held dynamometry (HHD) tests that were used to assess muscle strength of the Lumbo-Pelvic-Hip complex.

Test	Image	Muscles indicated[41]
Isometric adductor squeeze at 0° (ADD0)		Adductor magnus and gracilis
Isometric adductor squeeze at 60° (ADD60)		Adductor longus
Isometric adductor squeeze at 90/90° (ADD90/90)		Pectineus and adductor brevis
Side-lying hip adduction (Hip ADD)	 5cm above medial malleolus	Adductor magnus, gracilis, adductor longus, pectineus and adductor brevis

Side-lying hip abduction (Hip ABD)	 5cm above lateral malleolus	Gluteus medius, minimus and tensor fascia latae
Prone hip extension (Hip EXTN)		Gluteus maximus, adductor magnus, hamstrings

Hip adduction, abduction and extension were measured on the players' dominant leg using a hand-held dynamometer (HHD) (Lafyette, USA)[22]. Once positioned, players were instructed to match the force of the tester for a period of 5-s. This 'make' technique is reported to have greater reliability than a 'break' test in dynamometry[23]. Players were given two practice trials to ensure the correct action was performed and the HHD score was recorded on the third attempt. Hip extension was recorded in the short lever position with the player in prone, knee flexed to 90^o and the HHD placed 5cm proximal to the knee joint line on the posterior thigh. Hip abduction was recorded with the player in side-lying position. The HHD was placed 5cm proximal to the lateral malleolus. Hip adduction was measured in side-lie with the HHD placed 5cm proximal to the medial malleolus. All testing was performed by a single investigator. The total time duration of testing for the squad was 60 minutes to complete from initial assessment to final assessment. Prior to the data capture the tester completed a reliability study (n=8, Adductor Squeeze at 0^o ICC = 0.998, SEM = ±10 mmHg; 60 ^{o} ICC = 0.987, SEM = ±7 mmHg; and 90 ^{o} ICC = 0.995, SEM = ±10 mmHg; extension = ICC = 0.989, SEM = ±1.9kg; adduction = ICC 0.957, SEM = ±1.3kg; abduction = ICC 0.993, SEM = ±1.6kg).

The players' baseline screening data was noted (ADD0 = 271± 53.4mmHg; ADD60 = 256 ±41.2;mmHg ADD 90/90 = 226 ±45.6mmHg; Hip Extn = 42.4 ±7.4Kg; Hip ADD = 42.2 ± 6.7Kg; Hip ABD 29.4 ± 5.0Kg).

Following the baseline screening, players were then required to complete a Yo-Yo intermittent recovery test level 1 [Yo-Yo IR-1[24]] until voluntary exhaustion. The Yo-Yo IR1 testing was administered by strength and conditioning staff on two occasions with players grouped according to position (forwards and backs). Immediately (within 90seconds) after each player had finished the Yo-Yo IR-1 test, the screening assessments were repeated for all players.

Groups were determined using hierarchical cluster analysis of the preferred leg data. Figure 1 shows the distributions of the change in scores of each screening test from baseline following the YoYo IR-1 test for each cluster. These observations characterised the groups and prehabilitation priorities were identified (exercise themes) and tailored to address the likely associated issues (Table 2).

Figure 1shows the distributions of the change in scores from baseline following the YoYo IR-1 test by cluster (group)

Cluster 1 (N = 4, all backs, Stature = 181.8 ± 6.7 cm and Mass = 94± 8.7 kg, one player with previous medical history of LPH injury in previous 12months); showed increases in hip adductor squeezes in all three positions, and a reduction in hip extension strength post Yo-Yo IR-1.

Cluster 2 (N = 18, six backs and 12 forwards, Stature = 185.3 ± 6.7 cm and Mass = 105.5 ± 12.7kg; six players with previous medical history of LPH injury in previous 12months) showed similar responses across all hip and groin tests post Yo-Yo IR-1.

Cluster 3 (N = 6, one back and five forwards, Stature = 191.5 ± 6.9 cm and Mass = 110.6 ± 14.1 kg, no previous medical history of LPH injury in the past 12months) showed reductions in 60^{o} adductor squeeze, hip extension strength and hip adduction strength. Cluster 3 also demonstrated an increase in hip abduction strength post Yo-Yo IR-1.

The remaining 22 players not tested (Stature = 185.2 ± 5.2 cm and Mass = 102.7 ± 10.8 kg) were composed of 10 backs and 12 forwards and one player with previous medical history of LPH injury in previous 12months.

The prehabilitation was delivered as auxiliary exercises in the player's lower limb strength and conditioning sessions throughout the rugby season (a total of 2 sessions per week for 47 weeks, mean 1.8 ± 0.4). A Graduate Sports Therapist and the Strength and Conditioning Coaches supervised each session. The supervision ensured that each player executed the exercises with the heaviest load possible to maintain appropriate technique as per the prevention programme.

TABLE 2 Characteristics and prehabilitation priorities for each cluster

Cluster	Characteristic	Exercise theme 1	Exercise theme 2	Rationale
One	Weakness of hip extension under fatigue	Low threshold deep hip rotator cuff	High threshold gluteus maximum loading	Gluteus Maximus is both a prime mover for hip extension and lateral rotation[41]. Gluteus maximus and medius work synergistically in the control of frontal plane stability of the hip and so deep hip stabilisers should also be considered[42].
Two	Generic weakness under fatigue	Lower abdominal control	Adductor strengthening	An anatomical relationship exists between the proximal adductor longus tendon and the contralateral distal rectus sheath that contributes to an anatomical pathway across the anterior pubic symphysis that permits the transmission of large forces during multidirectional athletic activities[43].
Three	Weakness of adductors, hip extensors and increases in hip abduction strength under fatigue	Inner range hip flexor strength	Lower abdominal control	Iliacus is an important stabilisers of the hip during the late stance phase of gait[44]. Synergistic activation of the abdominal and hip flexor muscles is important for controlling anterior pelvic tilt [41], which has the ability to increase lumbar lordosis and alter length tension relationships around the LPH complex
Non-clustered	N/A	Generic adductor strength	Generic abductor strength	Low absolute hip adductor strength and hip adductor to abductor ratio is associated with an increased risk of groin injury[13].

The effect of the preventative program was determined by a comparison of injury surveillance data between the previous (2014-15) season and 2015-2016 season. All soft tissue injuries to the buttock/pelvis, groin, thigh and lumbar spine (identified by their OSICS code, version 10.1[25]) sustained via a non-contact mechanism were identified from prospective injury surveillance data. Training and match injury incidence (per 1000 hours), injury prevalence (% of players unavailable) and average days-lost per injury were compared for all non-contact LPH injuries sustained over the two seasons.

Ward's Hierarchical cluster analysis was used to group players on the change (pre to post YoYo IR-1 test) for all hip and groin measures on the players' dominant leg. Consensus injury surveillance[8] methods were used for data analysis. A comparison was made between seasons for LPH injury incidence, severity, average number of days lost per injury and prevalence.

Results

When comparing the 2014-15 and 2015-16 season: total incidence of non-contact LPH injury per 1000hours remained stable (1.5 v 1.6); total severity of LPH was halved (936d v 468d); average time to return to play was reduced by 54% (78 ±126, min 3, max 285 v 42±37, min 5, max 111); and prevalence decreased by 2% (21 v 19).

At the group level, Cluster 1 sustained four LPH injuries resulting in a total of 65 days lost (median = 9, min = 0 max = 47d). Cluster 2 sustained four LPH injuries resulting in a total of 144 days lost (median = 16.5, min = 2, max = 109d). No player in cluster 3 sustained a time-loss LPH injury during the 2015-2016 season. Players in the control group sustained a total of 7 time-loss LPH injuries during the 2015-2016 resulting in 259 days lost (median = 21, min = 8, max = 111d).

Discussion

The aim of this study was to explore the impact that tailored prevention programmes had on reducing LPH injuries. Exercise selection for the preventive program was based upon grouping the players based on their responses to running to voluntary exhaustion on six measures of hip/groin assessments. Injury data were compared from the intervention season and the previous season. No meaningful impact as a result of the intervention was found since the number of non-contact LPH injuries remained stable compared to the previous season. However total severity (50%) and average severity per LPH injury (46%) in the 2015-16 season were both lower, when the preventative program was used, in comparison to the previous year. Moreover, total LPH injuries sustained by the non-clustered players were more severe by 50 days than clustered players.

The prehabilitation exercises were selected on the most prominent responses of hip and groin strength assessments to voluntary exhaustion inflicted by the YoYo IR-1. They were based upon a number of EMG studies that have evaluated the muscle activation of the gluteal muscles[27], adductors[28], abdominal muscles[29], abductors[30] and hip flexors[31].

Cluster 1, was characterised by a reduction in extensor strength and a marked increase in adductor strength post running. Whereas, reduced adductor strength featured on both clusters 2 and 3. In addition for cluster 2, fatigue of the adductors co-existed with reductions in the strength of the synergistic pairings (extensors and abductors), and in cluster 3, the reduction in adductor strength did not accompany a reduction in the adductors synergistic pairing with the abductors. In cluster three, the abductors strength increased post running.

Previously reductions in adductor strength have been observed and explained by fatigue of those associated muscles[20]. However, the observed increased adductor strength (cluster 1) and abductor strength (cluster 3) are possible compensatory strategies for fatigue during level running given that the adductors contract at toe-off and continue through to the early swing phase. It has been shown that localised muscle fatigue affected sagittal kinematics and compensatory strategies were developed to protect the lower limb joints during toe-off and swing phases of running gait[26]. Clinically this maybe explained as a feed forward phenomenon[32]. For example where the increases in adduction angle and adduction moment have potential to place the knee in a vulnerable position, the feed forward response would require anticipatory adjustments to muscle activation of the abductors[33] resulting in the observed increase in abductor strength post maximal running in cluster 3.

It is likely that LPH injury is the consequence of complex interactions between multiple risk factors and inciting events, thus any intervention aimed at reducing injury needs to be multifaceted and tailored to intrinsic risk factors. A small number of studies have implemented exercise-based injury prevention programs for the reduction of groin injuries however these have not tailored the intervention to the individual players, rather they have applied a one-size-fits-all intervention[13, 14].

We acknowledge a number of limitations of the present study. Firstly, using previous season's injury data is a limitation, we are unable to say with a high level of certainty what was observed was just natural variation. It should also be noted that the results cannot be generalised to other populations and are specific to this sample of professional rugby players. The Yo-Yo IR 1 test has been shown to be a reliable measure of aerobic fitness and a useful measure of intermittent high intensity performance in a range of team sports [34,35 36], however its use as a specific hip fatiguing test in professional rugby union player has not been established. Therefore the specific hip muscular fatigue that the rugby players are exposed to in matches are not comparable and may be perceived as a limitation of this study. Due to time constraints only the dominant leg was assessed using the HHD, thus we were unable to examine the role of asymmetry in the risk of LPH. Finally, we report HHD scores as Kg. We did not measure lever length and so cannot present normalised scores as Newtons/Kg BW[37].

Conclusion

We have described the process taken by a Sports Therapist in conjunction with Strength and Conditioning Coaches that reduced the impact of LPH injuries in a professional rugby club. Novel features of the process were the use: of hierarchical cluster analysis and the changes to LPH strength post fatigue. This method provided a more parsimonious framework for exercise selection. Despite there being no impact on reducing the incidence of LPH injuries, total severity and average severity of non-contact LPH injuries were reduced compared to the previous season. In addition, the total number of non-contact LPH injuries and total days lost was reduced when comparing clustered players prescribed to a control group. Hierarchical cluster analysis should be considered an effective tool in overcoming the logistics of implementing tailored programs from the information gained from screening.

Practical Implications

- The use of hierarchical cluster analysis may provide valuable information on how to group players to overcome logistical difficulties in implementing individualised tailored injury reduction programmes.

- A tailored injury prevention programme based upon changes in hip and groin strength under fatigue may reduce injury severity and prevalence in professional rugby union players compared to a generic exercise programme.

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