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The Correlation between Net Impulse and Phases of Linear Sprint Performance in University American Football Players

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ABSTRACT

Impulse has been proposed as a reliable performance measure when assessing force generating capacity, during a given time frame, and in recent literature has been investigated to its degree of relationship with sprint performance. This study investigated the correlation between early epochs of net impulse from isometric actions and selected phases of linear sprint performance. A within subject design was employed to assess the correlation between linear sprint performance and epochs of net impulse in 29 university American Football athletes (mean±SD: age = 20.10±1.53 years; height = 181.69±5.63cm; weight = 95.92±22.81kg). Net impulse was measured over epochs of 0-100, 0-150, and 0-200 milliseconds (Newtons per second) via an isometric mid-thigh pull protocol while linear speed was assessed using linear sprint testing (10 and 36.58 metres). Pearson's r correlation coefficient was used to evaluate correlations between assessed variables and effect size. The analysis demonstrated trivial to small correlations (r=-0.06 to 0.18) between early epochs of net impulse and linear sprint performance. The 10-metre linear sprint performance demonstrated small correlations at 0-150 milliseconds (r=0.18) while the remaining variables revealed trivial correlations. The effect size indicated trivial to small correlations between the assessed variables. Although no significant correlation was found between isometric mid-thigh pull metrics and linear sprint performance these findings provide meaningful insight into the complexity of sprinting mechanics, in the assessed population. If net impulse does not strongly correlate with sprint performance, it may indicate the need to reassess the emphasis placed on isometric strength assessments in sprint profiling.

Key words: Force-time Characteristics, Acceleration, Team Sport, Physical Profiling.

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1. Introduction

The sport of American football requires athletes to possess a series of athletic qualities such as strength, rate of force development, acceleration, and high running velocity to be successful (Fullagar et al., 2017; Philipp et al., 2022). Within the National Football League combine, amongst the physical qualities evaluated is the 40 yard (36.58 metres) linear sprint which represents explosive acceleration (Asprey et al., 2020; Thomas et al., 2015). There are a series of primary external forces that determine the acceleration of the centre of mass, during this assessed physical quality, which include ground reaction force, gravitational force, and wind resistance (Hunter et al., 2005). Primary qualities that influence these acting forces and therefore the kinetic success of sprint performance include the prescription of strength and power training (Allégue et al., 2023; Cunningham et al., 2013). Physiological factors, of strength and power training, that contribute to this success include storage and utility of elastic energy (functions of the stretch shortening cycle) as well as morphological factors such as muscle fibre type and muscle architecture. In addition, neural factors may include motor unit recruitment, synchronization and firing frequency (Allégue et al., 2023). Kinematic variables that can influence sprint performance include step length-frequency as well as contact-flight time (Lockie et al., 2014).

An emerging kinematic performance metric, impulse, is defined as the product of force and time, within a given time (Staunton et al., 2022). Merrigan et al. (2021) proposed impulse as a reliable performance measure when assessing static force generating capacity, and recent literature has investigated its degree of relationship with sprint performance. Thomas et al. (2015) examined the relationship between epochs of isometric impulse (at 100 and 300 milliseconds) and sprint performance (5- and 20-metres) in fourteen male collegiate soccer and rugby league players and identified very strong inverse correlations with sprint performance at epochs of ≤300ms (r= -0.71 to -0.78; $p \leq 0.01$). More recent investigations by Brady et al. (2020) explored the relationship between variables of isometric strength (impulse at 200ms) and sprint acceleration (0-5 metre split time) in fifteen male sprinters identifying significant correlations (r= -0.58; $p \leq 0.02$). There does not appear to be clarity as to the exact variable of impulse applied to define a relationship, with prior studies largely considering absolute impulse as opposed to net impulse which considers the total impulse impressed minus contribution of a given athlete's weight (Cleather, 2018). In addition, while these studies have investigated a variety of athletes, no known studies have investigated American Football athletes despite the sport's popularity and physical requirements. Comfort et al. (2019) suggested that isometric impulse provides valuable performance information however more research is still needed to learn how best to utilise this measurement for sports performance monitoring and assessment. Furthermore, Thomas et al. (2015) expressed the value impulse offers when investigating the relationship between static strength and dynamic performance. This study aims to investigate the relationship between early epochs of net impulse production and specific phases of linear sprint performance, particularly focusing on the accelerative and maximal velocity phases. The primary objective of this investigation is to assess the strength of this relationship to better understand the impact of early net impulse on sprint performance.

2. Methods

2.1 Experimental Design

A within subject design was employed to assess the correlation between linear sprint (LS) performance and epochs of net impulse in American Football athletes at a University in England between March and July 2024. LS was recorded over 10 metres (m) and 36.58m (40 yards), tested in the same effort (Fullagar et al., 2017; Kraemer et al., 2016). Net impulse was measured via an isometric mid-thigh pull (IMTP) 48 hours after LS testing to provide a wash-out period. Ethics were approved by the University of Gloucestershire, UK (REC.23.113.5). Upon official recording, participants completed a period of familiarisation, for both the LS and IMTP. LS testing was completed on an indoor third generation artificial grass surface to ensure consistency of weather conditions while IMTP testing was completed in a single weight room, on a standard four-point squat rack. The testers and their role, for all data collection, remained the same throughout.

2.2 Participants

Sample size was calculated using G*Power software, version 3.1 (Kang, 2021) with 29 participants required. Following sample size calculation (population correlation: 0.5 effect size, alpha: 0.05, power analysis: 0.80, null hypothesis correlation: 0), 29 male athletes were recruited from a single University American Football team in England. All participants had regularly engaged in a competitive sports environment as well as a resistance training programme for at least one year prior to completing testing during the study. All participants completed a medical questionnaire, detailing previous injuries. Anyone who had sustained an upper or lower-limb injury in the previous 2 months or did not deem they had fully recovered from an injury sustained longer ago, were excluded prior to testing.

2.3 Testing Procedures

- **LS Testing**

Participants conducted a ten-minute sprint specific warm up inclusive of familiarity of the set position (figure 1). Participants' starting line was allocated fifty centimetres behind the 0m timing gate, further than 20 centimetres used in previous studies, to eradicate triggering the timing gate (Allégue et al., 2023). Timing gates (TCi, Brower Timing Systems, Utah, USA) were set at 0m and 36.58m with an isolated split time at 10m. Participants completed 3 maximal effort sprints and were provided with two minutes rest between efforts, with additional time required if requested (Allégue et al., 2023; Healy et al., 2019). Participants were instructed to run as fast as possible, through the full 36.58m distance, and to refrain from deaccelerating until passing the gate (Healy et al., 2019). Scores from each sprint effort were averaged and analysed. Each sprint effort was recorded to the nearest millisecond (ms). All participants were instructed to rest for 48 hours prior to minimise physical fatigue (Brady et al., 2020).

Figure 1: Set Position Prior to Linear Sprint

- **IMTP Testing**

48 hours following the LS trials, participants performed IMTP testing which has shown good-excellent test-retest reliability (intraclass correlation coefficient range: 0.73-0.99) when assessing maximum strength (Grgic et al., 2022). Prior to testing, participants performed a standardised warm up that consisted of a 5-minute stationary cycle (at a moderate pace), 10 alternating bodyweight lunges and 10 body weight squats (McCormick et al., 2022). For familiarisation, of the IMTP testing procedure, participants were given 3 practice trials at 60%, 75% and 90% of maximal perceived exertion. Each practice trial lasted 4 seconds and were separated by 1 minute rest periods between efforts. Following the practice trials, participants completed 3 recorded trials following the same work-to-rest ratio (McCormick et al., 2022; Thomas et al., 2017).

Figure 2: Visual depiction of IMTP

The height of the bar was positioned to reflect the initial phase of the second pull position, during a power clean (figure 2). Final positioning of the bar resulted in knee and hip angles ranging between 125-145° and 140-150°, respectively (Comfort et al., 2019). Knee and hip angles were established using a goniometer and were standardised across all trials. Prior to the first practice trial, each participant positioned themselves, bi-laterally, on the dual force-plate platform system (FD Lite-0308, Forcedecks, Vald Performance, Australia), positioned directly under the set bar, for a period of quiet standing to gather their bodyweight (this value was included in the collected metric measurements). All trials were conducted on an improvised portable rig, which permitted changes (3.5-centimetre intermissions) in bar height setting. A standard 20-kilogram Olympic bar (steel-based**)** was used throughout the testing protocol. Throughout all trials, participants applied a hip width apart hand grip to the bar. Hands were secured to the bar via application of standardised lifting straps (Elkins, 2020) with familiarisation, of application, provided prior to trial commencement.

To maintain clear understanding and consistency throughout, participants were guided throughout all trials, with clear instruction. Prior to the initiation of the pull, participants were instructed to alleviate slack between the bar and portable rig to minimise pre-tension (Thomas et al., 2017). Prior to each recorded trial, a general instruction of *"when you pull, how much force you can produce, and how quickly you can produce that force shall be measured"* was administered. This was immediately followed by *"focus on pulling as hard and as fast as possible" (Halperin et al., 2016)*. Prior to each trial, participants were provided an auditory *"3,2,1, pull"*. Immediately following this instruction an auditory *"4,3,2,1, stop"* was provided. No other encouragement or feedback was provided throughout the testing. If there was any visible countermovement motion at the start of a pull, the recorded trial was discarded and repeated under the same protocol. Data was recorded at 1000Hz (Carroll et al., 2019). Recorded values were exported and analysed. Metrics analysed were impulse (net of bodyweight) over 0-100ms Newtons per second (Ns), 0-150ms Ns, and 0-200ms Ns, which reflected force-time variables (Merrigan et al., 2021; Morris et al., 2018).

3. Statistical Analysis

Data collected was normally distributed and thus Pearson's r correlation of coefficient analysis (SPSS 28.0.0.0 190) was used in conjunction with the direction of correlation (positive or negative) to evaluate correlations between the following variables: 10m and 100ms, 10m and 150ms, 10m and 200ms, 36.58m and 100ms, 36.58m and 150ms, and 36.58 and 200ms. Correlation and effect scales were set as 0.1-0.29 (small), 0.3-0.49 (moderate) and >0.5 (large).

4. Results

Pearsons r correlation coefficients between IMTP variables and LS performance are presented in Table 2. The correlations ranged from trivial to small correlations (r=-0.06 to 0.18) for early epochs of net impulse and LS performance (Table 3). Specifically, 10 metre LS performance showed a small correlation at 0-150 milliseconds (r=0.18). While remaining variables exhibited trivial correlations. Effect sizes similarly indicated trivial to small relationships.

Table 1: Participant Characteristics

Variable	***Participants (n=29)***
Age (years)	20.10 ± 1.53
Height (centimetres)	181.69 ± 5.63
Weight (kilograms)	95.92 ± 22.81

Note: Data reported with mean ± standard deviation

Table 2: *Pearsons r correlation coefficient between IMTP variables and sprint performance (n = 29)*

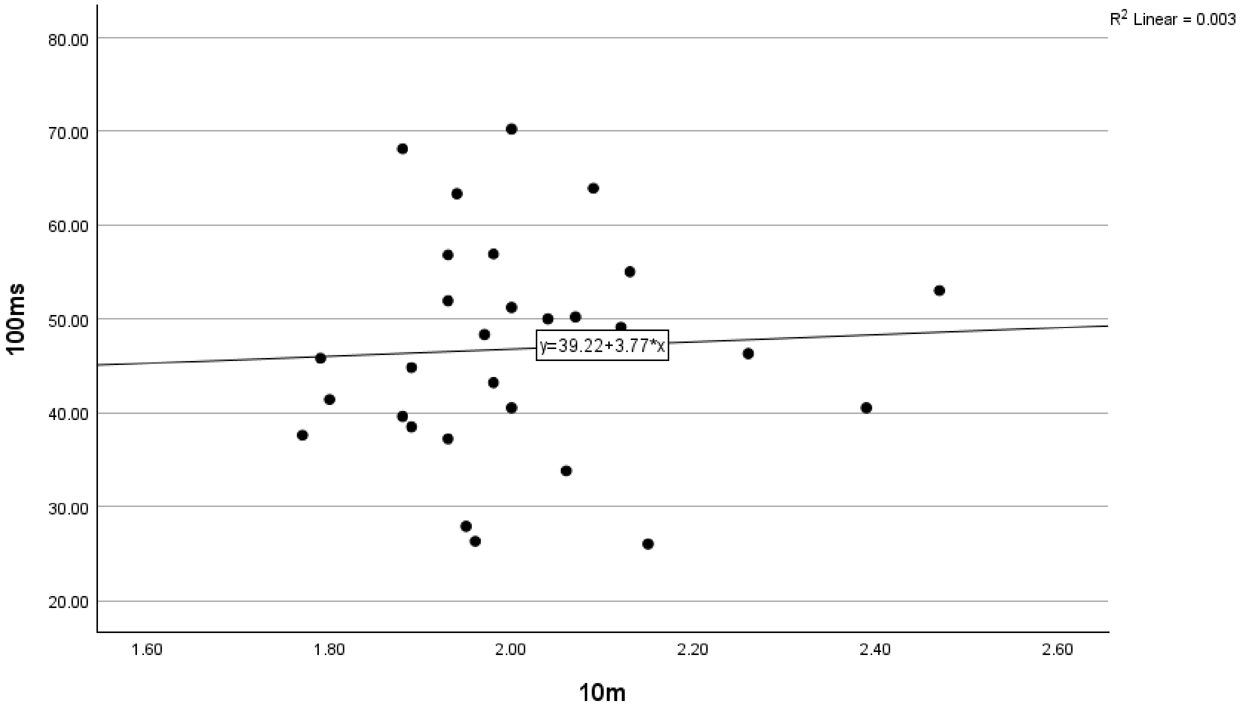
Variables Correlated	***Pearsons r Correlation***	***Effect Size***
10 metres and 100 milliseconds	0.05	Trivial
10 metres and 150 milliseconds	0.18	Small
10 metres and 200 milliseconds	0.09	Trivial
36.58 metres and 100 milliseconds	-0.06	Trivial
36.58 metres and 150 milliseconds	0.06	Trivial
36.58 metres and 200 milliseconds	0.01	Trivial

Table 3: Descriptive results of assessment variables (n = 29)

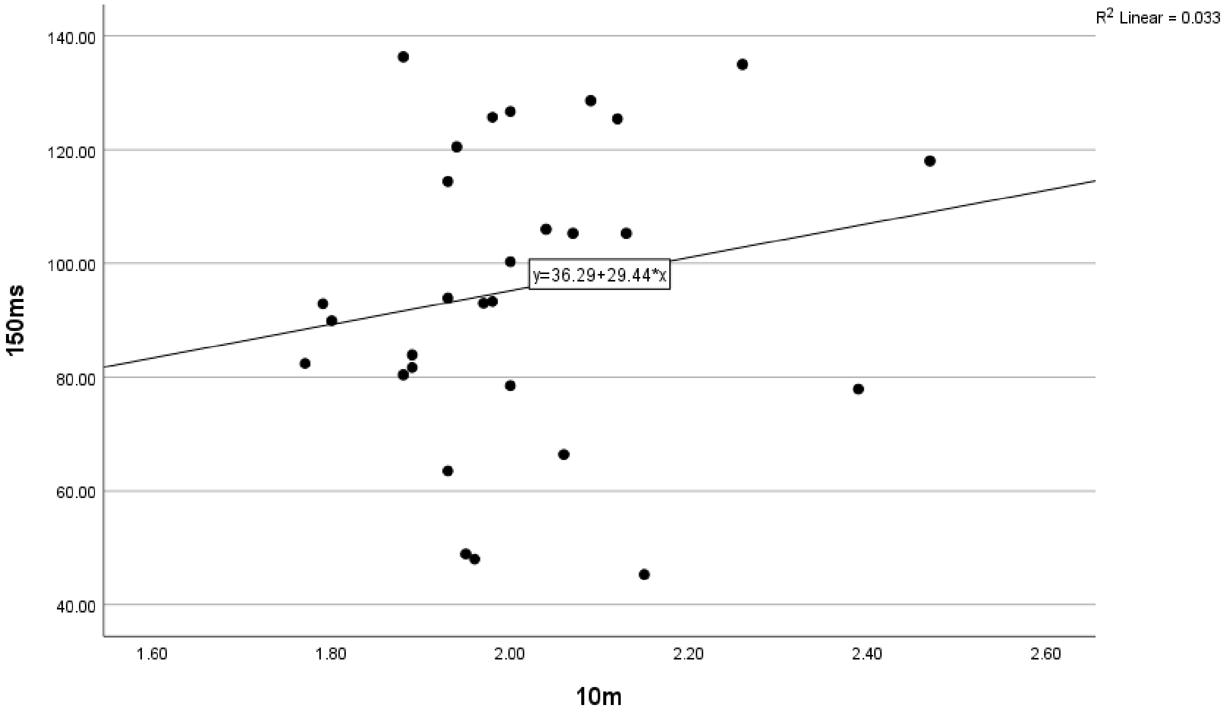
Assessment Variables Scores	***Mean Score***	***Standard Deviation***
10 metre sprint (seconds)	2.01	0.16
36.58 metre sprint (seconds)	5.45	0.47
IMTP 100 milliseconds (Ns)	46.80	11.58
IMTP 150 milliseconds (Ns)	95.42	26.12
IMTP 200 milliseconds (Ns)	155.23	40.37

Figure 3: Scatterplots for 10-metre correlations

a) 10 metres and 100 milliseconds



b) 10 metres and 150 milliseconds



c) 10 metres and 200 milliseconds

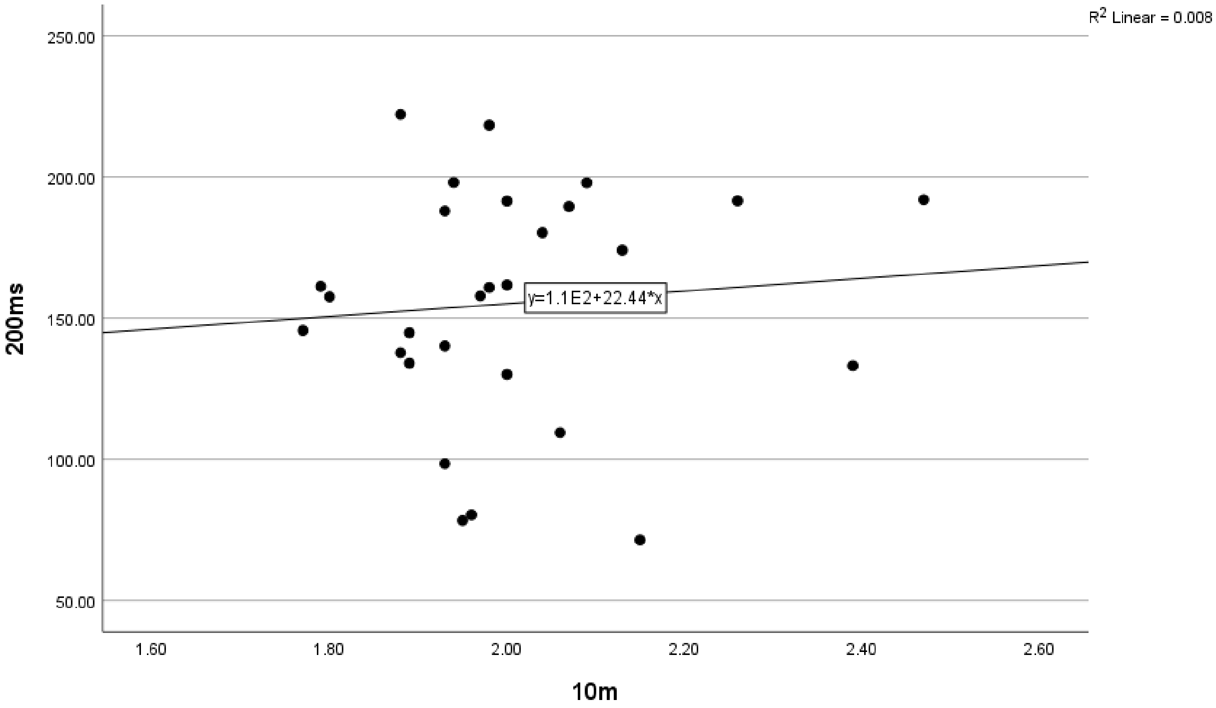
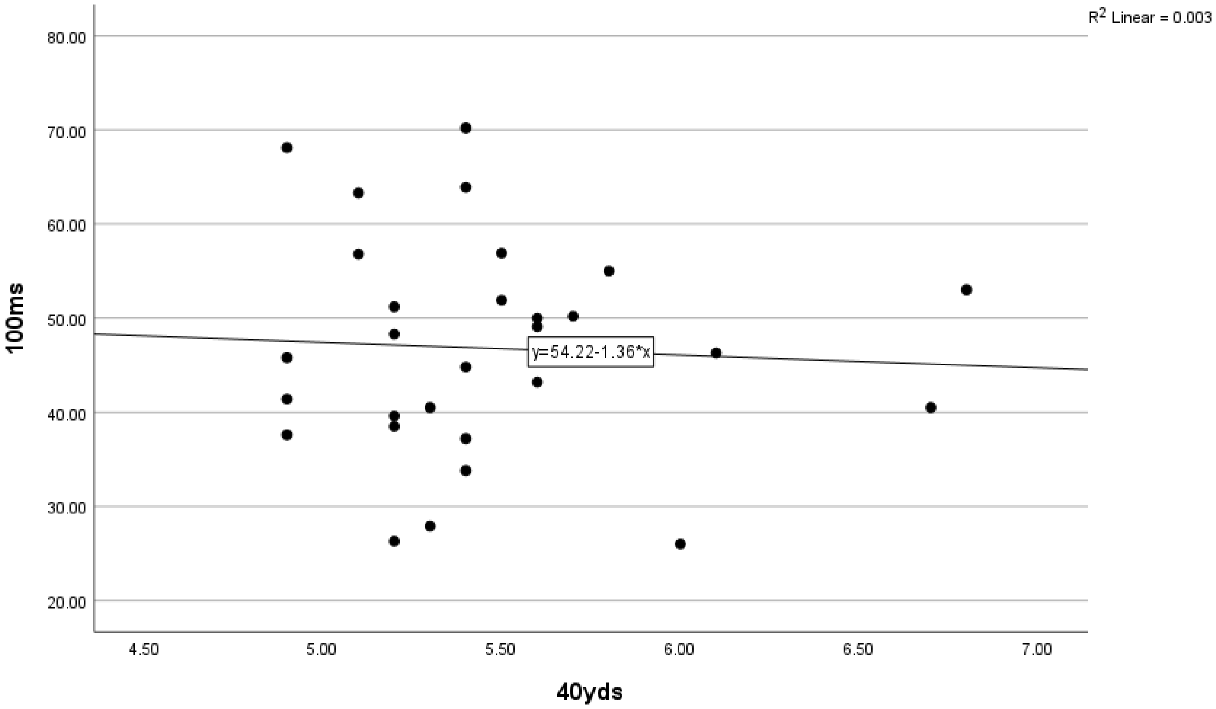
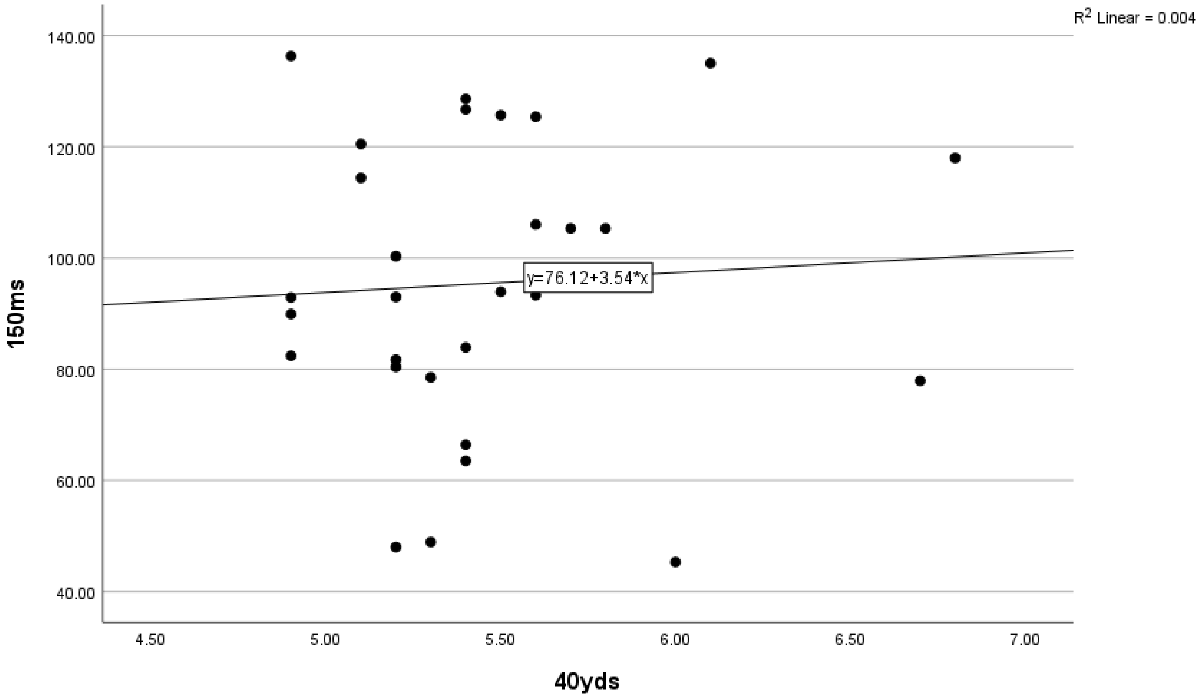


Figure 4: *Scatterplots for 36.58-metre correlations*

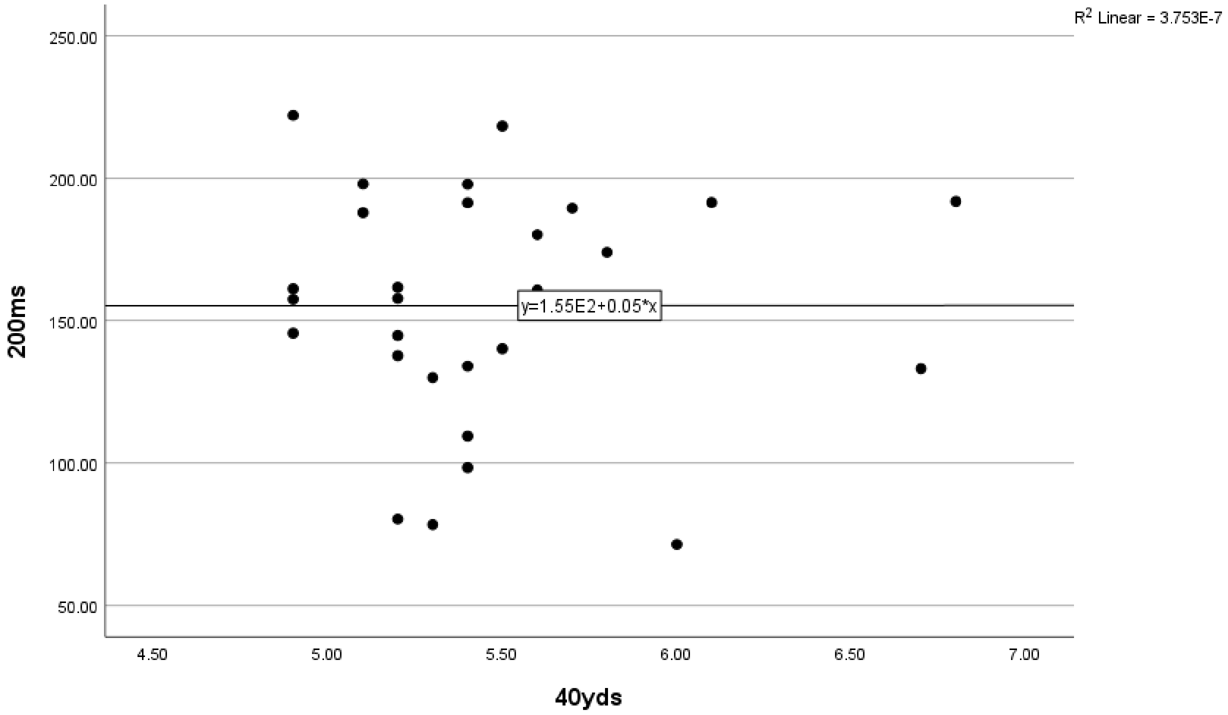
a) 36.58 metres and 100 milliseconds



b) 36.58 metres and 150 milliseconds



c) 36.58 metres and 200 milliseconds



5. Discussion

The present study examined the relationship between early epochs of net impulse and selected phases of LS performance (10 and 36.58m). The results demonstrated small-trivial correlations, which do not align with Thomas et al. (2015) reported correlations (r= -0.07 to -

0.08) between early epochs of impulse and accelerative sprint performance. A notable methodological difference is the sprint distance analysed; Thomas et al. (2015) assessed 5 and 20m distances, whereas the current focused on 10 and 36.58m. The inclusion of the 36.58m distance aimed to replicate the National Football League's combine's linear sprint test and examine whether early net impulse contributes to maximal velocity sprinting. However, the results indicate minimal relevance of this distance in evaluating the relationship between early net impulse and linear sprint performance.

Thomas et al. (2015) reported strong correlations at 5 and 20m, whereas the current study found only small-to-trivial correlations. A potential explanation for this disparity is the differences in mean impulse output at 100ms performed during the IMTP assessment. Thomas et al. (2015) recorded higher mean impulse output at 100ms (77.06Ns) compared to the present study (46.80Ns). Although this factor alone is not conclusive, it suggests that participants in the present study may have been unable to generate sufficient vertical impulse on the dual force-plate potentially affecting the accuracy of the assessed relationships. Additionally, participant familiarity with the IMTP protocol may have influenced the results. Despite efforts to ensure adequate familiarisation, learning effects may have played a role. Future studies should consider implementing separate familiarisation and assessment sessions to minimise potential learning effects and improve measurement reliability (McCormick et al., 2022).

The results of this study indicate that shorter sprint distances may be more relevant when assessing the relationship between early net impulse and LS performance. Specifically, the most appropriate distances for evaluation appear to be between 5 and 20m. Moreover, the understanding of foot touchdown kinematics and external force application during early acceleration is still in development (Bezodis et al., 2019; Hunter et al., 2005). Therefore, further research is needed to solidify this relationship, particularly within field-based athletes such as university American football playing populations (Rumpf et al., 2016).

The set position used during the LS performance protocol is an important consideration. Prior research has predominantly employed a two-point stance when assessing LS performance (Dietze-Hermosa et al., 2021; Thomas et al., 2015). In contrast, the current study implemented a three-point stance to standardise participant positioning and eliminate variability associated with individual stance preferences. Bezodis et al. (2019) identified notable biomechanical differences between elite and sub-elite sprinters using a three-point stance. Specifically, sub-elite sprinters tend to adopt lower front and rear hip flexion (80° and 89° respectively), reduced rear knee extension (117°), and decreased front knee flexion (91°) compared to their elite counterparts. Given that participants in the present study were classified as sub-elite, they may have been unable to assume an elite three-point stance, which could have influenced their ability to generate maximal ground reaction forces.

The current study's findings contrast with those of Brady et al. (2020), who identified a significant relationship between impulse at 200ms and sprint acceleration (0-30m) in male sub-elite sprinters, particularly within the 0-5m phase. A notable methodological distinction is the use of starting blocks in Brady et al. (2020), whereas the present study did not incorporate blocks. Wild et al. (2018) emphasised the necessary body orientation adjustments between block and non-block starts, which may have affected acceleration mechanics and, consequently, the observed correlations in this study. Brady et al. (2020) and Thomas et al. (2015) assessed absolute impulse at 100 and 300ms, and 100 and 200ms, respectively. Absolute impulse includes the participants body mass, whereas the present study utilised net impulse, which subtracts body mass from total impulse. This approach provides a more precise measure of an individual's isometric performance during the IMTP assessment. Future research should explore additional force-time metrics, including net braking impulse (eccentric phase) and propulsive impulse (concentric phase), to further dissect the mechanisms athletes use to maximize impulse output and improve sprint acceleration.

6. Conclusion

This study found no significant correlation between IMTP metrics and LS performance, reinforcing that sprinting is a multifaceted skill influenced by neuromuscular, biomechanical, and technical factors rather than net impulse alone. These findings suggest that net impulse may not be a strong predictor of sprint ability, emphasising the need for future research to explore additional contributors, such as muscle architecture, tendon stiffness, motor unit recruitment, and step kinematics, for a more comprehensive understanding of sprint performance.

7. Practical Applications

For strength and conditioning professionals, these findings call into question reliance on isometric strength assessments for sprint profiling. Instead, practitioners should consider incorporating dynamic force-time metrics, reactive strength measures, and sport-specific sprint assessments to better inform training interventions. Future studies should examine a range of sprint distances, force-velocity profiling, and the role of eccentric and concentric force contributions in sprint performance, particularly for field-based athletes such as American football players.

References

- Allégue, H., Turki, O., Oranchuk, D. J., Khemiri, A., Schwesig, R., & Chelly, M. S. (2023). The effect of combined isometric and plyometric training versus contrast strength training on physical performance in male junior handball players. Applied Sciences (Switzerland), 13(16), 1–13. https://doi.org/10.3390/app13169069
- Asprey, W. L., Foley, B. M., Makovicka, J. L., Dulle, D. L., Williams, K., Ginn, J., & Chhabra, A. (2020). A 10-year evaluation of the NFL combine: Do combine results correlate with career longevity for NFL offensive players? Physical Therapy and Rehabilitation, 7(1), 1–8. https://doi.org/10.7243/2055-2386-7-8
- Bezodis, N. E., Willwacher, S., & Salo, A. I. T. (2019). The biomechanics of the track and field sprint start: A narrative review. Sports Medicine, 49(9), 1345–1364. https://doi.org/10.1007/s40279-019-01138-1
- Brady, C. J., Harrison, A., Flanagan, E. P., Haff, G., & Comyns, T. M. (2020). The relationship between isometric strength and sprint acceleration in sprinters. Journal of Sports Physiology and Performance, 1, 38–45. https://doi.org/10.34961/researchrepository
- Carroll, K., Wagle, J., Sato, K., DeWeese, B., Mizuguchi, S., & Stone, M. (2019). Reliability of a commercially available and algorithm-based kinetic analysis software compared to manual-based software. Sports Biomechanics, 18(1), 1–9.
- Cleather, D. (2018). The little black book of training wisdom. 1–174.
- Comfort, P., Dos'Santos, T., Beckham, G. K., Stone, M. H., Guppy, S. N., & Haff, G. G. (2019). Standardization and methodological considerations for the isometric midthigh pull. Strength and Conditioning Journal, 41(2), 57–79. https://doi.org/10.1519/SSC.0000000000000433
- Cunningham, D., West, D., Owen, N., Shearer, D., Vinn, C., Bracken, R., Crewther, B., Scott, P., Cook, C., & Kilduff, L. (2013). Strength and power predictors of sprinting performance in professional rugby players. Sports Medicine and Physical Fitness, 53(2), 1–7.
- Dietze-Hermosa, M., Montalvo, S., Gonzalez, M. P., Rodriguez, S., Cubillos, N. R., & Dorgo, S. (2021). Association and predictive ability of jump performance with sprint profile of collegiate track and field athletes. Sports Biomechanics. https://doi.org/10.1080/14763141.2021.2000022
- Elkins, E. A. (2020). Effect of lifting straps on peak force during an isometric mid-thigh pull.
- Fullagar, H. H. K., McCunn, R., & Murray, A. (2017). Updated review of the applied physiology of American college football: Physical demands, strength and conditioning, nutrition, and injury characteristics of America's favorite game. International Journal of Sports Physiology and Performance, 12(10), 1396–1403. https://doi.org/10.1123/ijspp.2016-0783
- Grgic, J., Scapec, B., Mikulic, P., & Pedisic, Z. (2022). Test-retest reliability of isometric mid-thigh pull maximum strength assessment: A systematic review. Biology of Sport, 39(2), 407–414. https://doi.org/10.5114/biolsport.2022.106149
- Halperin, I., Williams, K. J., Martin, D. T., & Chapman, D. W. (2016). The effects of attentional focusing instructions on force production during the isometric mid-thigh pull. www.nsca.com
- Healy, R., Smyth, C., Kenny, I. C., & Harrison, A. J. (2019). Influence of reactive and maximum strength indicators on sprint performance. Journal of Strength and Conditioning Research, 33(11), 3039–3048. https://doi.org/10.1519/JSC.0000000000002635
- Hunter, J. P., Marshall, R. N., & McNair, P. J. (2005). Relationships between ground reaction force impulse and kinematics of sprint-running acceleration. Journal of Applied Biomechanics, 21(1), 31–43. https://doi.org/10.1123/jab.21.1.31

- Kang, H. (2021). Sample size determination and power analysis using the GPower software.* Journal of Educational Evaluation for Health Professions, 18, 1–6. https://doi.org/10.3352/JEEHP.2021.18.17
- Kraemer, W. J., Hooper, D. R., Kupchak, B. R., Saenz, C., Brown, L. E., Vingren, J. L., Luk, H. Y., DuPont, W. H., Szivak, T. K., Flanagan, S. D., Caldwell, L. K., Eklund, D., Lee, E. C., Häkkinen, K., Volek, J. S., Fleck, S. J., & Maresh, C. M. (2016). The effects of a roundtrip trans-American jet travel on physiological stress, neuromuscular performance, and recovery. Journal of Applied Physiology, 121(2), 438–448. https://doi.org/10.1152/japplphysiol.00429.2016
- Lockie, R. G., Murphy, A. J., Callaghan, S. J., & Jeffriess, M. D. (2014). Effects of sprint and plyometric training on field sport acceleration technique. www.nsca.com
- McCormick, B., Talpey, S., James, L., & MacMahon, C. (2022). The influence of instruction on isometric mid-thigh pull force-time variables. International Journal of Strength and Conditioning, 2(1). https://doi.org/10.47206/ijsc.v2i1.134
- Merrigan, J. J., Stone, J. D., Hornsby, W. G., & Hagen, J. A. (2021). Identifying reliable and relatable force–time metrics in athletes—Considerations for the isometric mid-thigh pull and countermovement jump. Sports, 9(1), 1–13. https://doi.org/10.3390/sports9010004
- Morris, R. O., Jones, B., Myers, T., Lake, J., Emmonds, S., Clarke, N. D., Singleton, D., Ellis, M., & Till, K. (2018). Isometric mid-thigh pull characteristics in elite youth male soccer players: Considerations by age and maturity offset. www.nsca.com
- Philipp, N. M., Crawford, D. A., & Fry, A. C. (2022). A total score of athleticism to estimate the amount of variance explained in on-field performance within collegiate American football players. International Journal of Strength and Conditioning, 2(1), 1–9. https://doi.org/10.47206/ijsc.v2i1.94
- Rumpf, M. C., Lockie, R. G., Cronin, J. B., & Jalilvand, F. (2016). Effect of different sprint training methods on sprint performance over various distances: A brief review. www.nsca.com
- Staunton, C. A., Abt, G., Weaving, D., & Wundersitz, D. W. T. (2022). Misuse of the term "load" in sport and exercise science. Journal of Science and Medicine in Sport, 25(5), 439–444. https://doi.org/10.1016/j.jsams.2021.08.013
- Thomas, C., Comfort, P., Chiang, C.-Y., & Jones, P. A. (2015). Relationship between isometric mid-thigh pull variables and sprint and change of direction performance in collegiate athletes. Journal of Trainology, 4, 1–6. http://trainology.org/
- Thomas, C., Comfort, P., Jones, P. A., Dos'Santos, T., & Santos, T. (2017). A comparison of isometric mid-thigh pull strength, vertical jump, sprint speed, and change-of-direction speed in academy netball players. International Journal of Sports Physiology and Performance. https://doi.org/10.1123/ijspp.2016-0317
- Wild, J., Bezodis, I., North, J., & Bezodis, N. (2018). Differences in step characteristics and linear kinematics between athletes, rugby players, and sprinters during initial sprint acceleration. European Journal of Sports Science, 18(10), 1327–1337.