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Does the leap-for-distance test correlate with short sprint performance in young soccer players? A between- and within-player analysis

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ABSTRACT

This study analysed the longitudinal relationship between short sprint time and the leap-for-distance test using novel motion tracking in young soccer players. Players (n = 144, age 14.8 ± 1.8 years) from six English Elite Player Performance Plan category three clubs completed two linear sprints (10 m, 20 m) and a leap-for-distance test (cm), on three to seven occasions across three seasons. Within-player (repeated measures) and between-player (mean of the repeated measures) correlation coefficients were calculated and stratified by pre- and post-peak height velocity (PHV). Very large, negative between-player correlations were found for leap-for-distance vs. sprint time (10 m: r = -0.70, 95% CI [-0.77, -0.61]; 20 m: r = -0.77, 95% CI [-0.83, -0.70]). Correlations were large for pre-PHV (10 m: r = -0.52, 95% CI [-0.71, -0.26]; 20 m: r = -0.62, 95% CI [-0.78, -0.39]) and moderate-to-large for post-PHV (10 m: r = -0.43, 95% CI [-0.60, -0.24]; 20 m: r = -0.54, 95% CI [-0.68, -0.36], respectively). Within-player correlations were trivial-to-small for all players (10 m: r = -0.14, 95% CI [-0.24, -0.06]; 20 m: r = -0.24, 95% CI [-0.34, -0.16]) and for pre-and post-PHV subgroups (r's < -0.30). Leap-for-distance is a useful discriminator of sprint performance but should not be used for tracking intra-player sprint changes in young soccer players, irrespective of maturation.

1. Introduction

Sprint speed is a key component of performance in modern soccer (Haugen et al., 2014), and straight sprinting is crucial in decisive match situations (Faude et al., 2012). Sprint distances in soccer usually range from 10 to 20 m, with most sprints being shorter than 20 m (Di Salvo et al., 2010). Sprint distances at ≤ 20 m are referred to as short sprint in different football codes (Nicholson et al., 2021). Sprint speed testing is common in boys' soccer academies, as it is used for talent identification (Unnithan et al., 2012) and monitoring physical performance (Williams et al., 2011). Regular monitoring of sprint capabilities in youth players can provide important information about neuromuscular fitness or fatigue status to inform training prescription. However, regular sprint testing may not always be feasible in an academy training environment, while excessive exposure to maximal velocities may place an undue risk of muscle injury, particularly if a player is fatigued (Small et al., 2009).

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Speed plays an important role in a young athlete's physical development and improvements occur naturally in children and adolescents due to anatomical growth and an increased stride length (Oliver et al., 2013). Increased force and power capacities, which are associated with increased stride length, are also trainable throughout childhood and adolescence (Oliver et al., 2013). The rate of speed development can change at different maturation stages in boys (Philippaerts et al., 2006; Towlson et al., 2018). Tracking changes in young soccer players' sprint performance alongside maturation status is therefore important for monitoring the physical development process, and for guiding training programming over extended periods (Wright & Atkinson, 2019; Wrigley et al., 2014). Despite the importance of speed, however, relatively few studies have examined long term changes in sprint performance in young male academy players (Williams et al., 2011; Wrigley et al., 2014).

Research has previously shown that jump and hop test scores are related to sprint performance (Holm et al., 2008; McFarland et al., 2016). These tests are easily administered and pose a reduced risk of adverse outcomes compared to sprinting. Adverse outcomes could mean longer recovery time, longer neuromuscular fatigue of sprints compared to jumps (Gathercole et al., 2015). Single leg horizontal hop distances are also related to acceleration performance in kinetics, including horizontal force and impulse (Morin et al., 2015), flight time, and contact time (Lockie et al., 2013), and kinematics, such as stride length (Lockie et al., 2013). However, accelerations (part of short sprint distance) in soccer are cyclical and consist of reciprocal movement patterns, which are more related to striding or leaping motion (i.e., left to right leg) than same-to-same leg horizontal hopping. A leap consists of applying horizontal force by taking off from one leg and contacting the ground with the other leg with the aim of achieving maximal horizontal distance as used with testing (Juris et al., 1997). Essentially, the leap is a locomotor foundational movement, which children and adolescents should be able to perform (Hulteen et al., 2018). Despite this, there are relatively few studies that have monitored leap in comparison to hop or jump tests. Previous research has used the leap in anterior cruciate ligament (ACL) rehabilitation but used subjective criteria (Juris et al., 1997). Juris et al. (1997) studied maximal-hop-for-distance and a maximal controlled leap. The maximal horizontal force production of a leaping skill as a pure performance measure without the need to worry about controlling the landing against short sprint performance has not been studied yet.

More recently, an objective and technologically advanced motion tracking movement screening tool has been developed to assess movement skills in academy soccer players (Athletic Movement Analysis Tool [AMAT] Performance). This system has shown high validity against manual measurements for dynamic movements (jumping, hopping, leaping) and technical static marker reliability (Wijnbergen, 2019). Using AMAT in academy soccer players has also demonstrated high (Malcata et al., 2014) between-session reliability for the leap-for-distance test (Intraclass Correlation Coefficient [ICC] = 0.76, 90% CI [0.46, 0.90]; Laas et al., 2021). However, there is a lack of longitudinal data tracking fundamental movements such as the leap-for-distance over time in youth athletes. Furthermore, understanding the one off and longitudinal association between leap-for-distance and sprint performance provides insight into the leap-for-distance test's feasibility as a validity and pragmatic predictor of sprint testing both within- and between-players.

The objectives of the current study were therefore to evaluate longitudinal changes, both between- and within-players, in short sprint performance (10 m, 20 m) in relation to the leap-for-distance test in young male academy soccer players, including stratification by maturation. It was hypothesised that longer leap distance would be correlated with faster sprints, and changes in both measures would be related.

2. Methods

2.1. Design

A longitudinal cross-sectional design was used to assess the relationship between short sprint time (10 m, 20 m) and leap-for-distance (assessed via motion tracking) in young soccer players. Players performed the sprint and leap-for-distance tests across three seasons (2017/18, 2018/19, 2019/20). Measurements took place during the players' regular physical performance testing at their club throughout each season. The players were tested up to seven times throughout the course of this study.

2.2. Participants

Three-hundred and five young soccer players from six category three clubs (U12 to U18 age groups) within the English Elite Player Performance Plan (EPPP) system participated in the study. A number of players had to be withdrawn from the study due to various reasons (injury, absence, release), as a minimum criterion of three data points was required for both the sprint tests and leap-for-distance. This rendered a final sample size of n = 144 (age = 14.8 ± 1.8 years; height = 167.6 ± 11.9 cm; body mass = 56.3 ± 13 kg; years from peak height velocity [YPHV] = 0.6 ± 1.6 years). There were three to seven paired (sprint and leap-for-distance) data points per player and the average test-to-test time period was 4.4 ± 1.7 (within-player 4.2 ± 2.4) months. Not all players were assessed at all time-points due to various reasons, including absence and injury, etc. The players' biological age was estimated via the maturity offset (in years) from YPHV (Mirwald et al., 2002) and categorised as pre-PHV or post-PHV (Portas et al., 2016). This equation was chosen because it is a non-invasive and practical method to estimate biological age in soccer academies (Portas et al., 2016; Towlson et al., 2018). The same formula has been used previously to detect the maturity offset of young soccer players in the ages as in this study (Mendez-Villanueva et al., 2011; Murtagh et al., 2018; Portas et al., 2016). The anthropometric measurements (height, sitting height, weight) were assessed by qualified sport scientists with minimum of three years of experience in recording anthropometric data who followed the International Society for the Advancement of Kinanthropometry (ISAK) guidelines when conducting the assessments. All players were injury-free and medically cleared to participate in training by the club's medical staff. Ethics release was obtained from Teesside University's School of Health and Life Sciences Research Ethics Committee to use anonymised data provided by Pro Sport Support Ltd. The study was conducted in accordance with the Declaration of Helsinki.

2.3. Procedures

Two attempts of each sprint and each leap-for-distance test (left to right, right to left) were recorded in each session, with sprints separated by 2 min and leap-for-distance test by 30 s recovery. The leap-for-distance test was undertaken indoors (e.g., gym, sports hall) and sprints were mostly performed outside on a 3G pitch, with one club using an indoor sports hall. The players wore soccer boots in outdoor sprint testing and their normal indoor training footwear during indoor leap-for-distance testing. The players in one club where sprints were done in an indoor hall used their normal indoor training footwear for both leap-for-distance and sprint testing.

Linear sprint speed was assessed via 20 m sprint tests with split times taken at 10 m and 20 m using single beam timing gates (Brower Timing Gate Systems, USA). The height of the timing gates was standardized at approximately the players' hip height (Haugen & Buchheit, 2016): 75 cm from the ground to the top of the camera lens for the U12 to U14 age groups and 95 cm for the U15 age-groups and older. This is the standard procedure for EPPP academy performance testing (Taylor et al., 2019). Players started 1m behind the first timing gate in a 2-point split stance position and were instructed to set off at a self-selected time and sprint maximally past the 20 m timing gate. The players had a 10-minute dynamic warm-up delivered by an accredited strength and conditioning coach prior to each testing session. The standardized warm-up included jogging, activation (squats, lunges, side lunges), mobility (leg kicks, open/close the gate, hamstring sweeps, etc.), shuffling, bounding, and sprinting movements. After their warm-up, the players had one practice sprint prior to the recorded trials.

Leap-for-distance testing took place in the gym or sports hall at each club. Players wore their normal indoor training footwear and reflective markers were attached to the middle of their shoelaces and above the patella, as per the manufacturer's user guidelines. This process was carried out from valid and reliable procedures (Laas et al., 2021; Wijnbergen, 2019) which have been successfully used to assess movements in soccer academies (Laas et al., 2020; Laas et al., 2021). The tests started and finished with an auditory cue from the AMAT system, which was explained to the players beforehand. The maximum movement performance outcome score was tracked by the 30 Hz depth sensor camera (Kinect™ V2, Microsoft, USA) throughout movement testing, indicating the distance where the players landed following their leap. The leap-for-distance performance was measured in mm (later converted to cm) as the front position of the landing foot from the start position in the anterior-posterior plane. For the leap-for-distance left to right leg test, the players started with their toes behind the start line and both feet flat on the floor. They performed the test on the audio cue and were instructed to "bend [their] left leg, push off with the left foot, hop as far as possible and land on the right foot", these instructions were replicated vice versa for the right to left side. No restrictions were placed on the arm movement and stabilizing the landing was not necessary. The players performed two trials of the leap-for-distance left to right leg followed by two trials on the opposite side, in that order (according to the manufacturer guidelines, previously found high reliability with youth soccer players; Laas et al., 2021).

2.4. Statistical analysis

Statistical analyses were performed in R (version 3.6.1, R Foundation for Statistical Computing, Vienna, Austria). The mean of the left and right side was used to create a 'leap-for-distance score' for each trial. The best (furthest) score of two trials and the best (fastest) sprint times were retained for the analyses. Baseline player characteristics and outcome measures are presented as mean ± standard deviation (SD).

Calculating the overall correlation between two variables with repeated measures can lead to erroneous conclusions as a result of pseudoreplication. Therefore, to determine if players who leaped further also had faster sprint times, the between-player means of each outcome measure were correlated, which is appropriate to remove within-subject differences (Bland & Altman, 1995b). To determine whether a change in leap-for-distance performance was associated with a change in sprint performance in an individual, the within-player correlations via parallel slopes general linear models (ANCOVA) (Bland & Altman, 1995a) were calculated, using the rmcorr package (Bakdash & Marusich, 2017). This is an appropriate method to remove between-subject differences (Bland & Altman, 1995a). All correlation coefficients were presented with 95% confidence intervals (CI) as markers of uncertainty in the estimates, using a bias corrected accelerated bootstrapping technique of 2000 samples with replacement from the original data (Bakdash & Marusich, 2017). Initial plot visual inspection revealed that the leap-for-distance scores and sprint times both had a higher correlation with biological age compared to all other (potentially confounding) growth-related variables (i.e., body mass, height, leg length). Given the high correlation with the tests and the potential influence of biological age on the young soccer players' physical performance (speed and power) (Mendez-Villanueva et al., 2011; Murtagh et al., 2018), the groups were later stratified using maturity offset, either pre-Peak Height Velocity (PHV) or post-PHV (Portas et al., 2016), before the between-player and within-player correlation analyses were run on the stratified data. There was a bias towards more mature players (pre-PHV, n = 43 vs. post-PHV, n = 81). Twenty players belonged to a 'mixed' group, who started out in the pre-PHV group but changed to the post-PHV group in the course of the data collection; they were excluded from the correlation analyses.

The magnitude of the correlation coefficients was interpreted using the following thresholds: less than 0.1 as trivial, 0.1 to 0.3 as small, 0.3 to 0.5 as moderate, 0.5 to 0.7 as large, 0.7 to 0.9 as very large, 0.9 to 1.0 as nearly perfect, and equivalent to 1.0 as perfect (Hopkins et al., 2009). To compare the two maturation groups, the 95% confidence interval was calculated for the difference between the mean correlation coefficients (Hopkins, 2006). The minimal threshold for smallest practically important difference in correlation coefficient between the two groups (rdif) was selected as ± 0.10 (Hopkins, 2006).

3. Results

For the leap-for-distance and sprint testing, six players were tested on all seven occasions, 14 players on six occasions, 25 players on five occasions, 76 players on four occasions, and 144 players on three occasions (Table 1). Table 1 shows the players' leap-for-distance and sprint outcome measures at each of the data collection time points (T1 – T7).

Table 1: The players' sprint and leap-for-distance scores across the different time points (T).

	T1	T2	T3	T4	T5	T6	T7
n	144	144	144	76	25	14	6
Sprints (s)							
10 m	1.80 ± 0.10	1.80 ± 0.10	1.79 ± 0.10	1.77 ± 0.09	1.77 ± 0.09	1.76 ± 0.07	1.79 ± 0.06
20 m	3.17 ± 0.20	3.16 ± 0.19	3.12 ± 0.19	3.12 ± 0.17	3.09 ± 0.16	3.06 ± 0.14	3.13 ± 0.15
Leap (cm)							
Leap	202.5 ± 21.1	205.9 ± 20.6	206.3 ± 21.4	207.3 ± 19.9	209.9 ± 20.7	213.0 ± 16.8	208.1 ± 17.4
Leap L-R	204.3 ± 21.6	207.4 ± 22.5	207.6 ± 22.4	210.2 ± 21.0	210.3 ± 21.2	215.4 ± 20.0	213.1 ± 21.6
Leap R-L	200.7 ± 22.0	204.3 ± 20.4	205.0 ± 22.4	204.5 ± 20.0	209.6 ± 21.8	210.5 ± 15.6	203.2 ± 14.9

Note: Values are represented as mean ± standard deviations. T = time points; Leap = leap-for-distance; Leap L-R = leap-for-distance left to right leg; Leap R-L = leap-for-distance right to left leg.

The between-player mean of repeated measures correlation coefficients for leap-for-distance were very large with 10 m (r = -0.70, 95% CI [-0.77, -0.61]) and 20 m linear sprint times (r = -0.77, 95% CI [-0.83, -0.70]). The noticeable negative correlations are visible from the negative slope with both distances in Figure 1A and 1B. The within-player correlation coefficients for leap-for-distance against 10 m (r = -0.14, 95% CI [-0.24, -0.06]) and 20 m (r = -0.24, 95% CI [-0.34, -0.16]) were small. The lack of within-player relationships is visible from the different directions of the individual slopes in Figure 2. Individual within-player correlations between leap-for-distance and sprint performance ranged between -1.0 and 1.0 for both sprint distances.

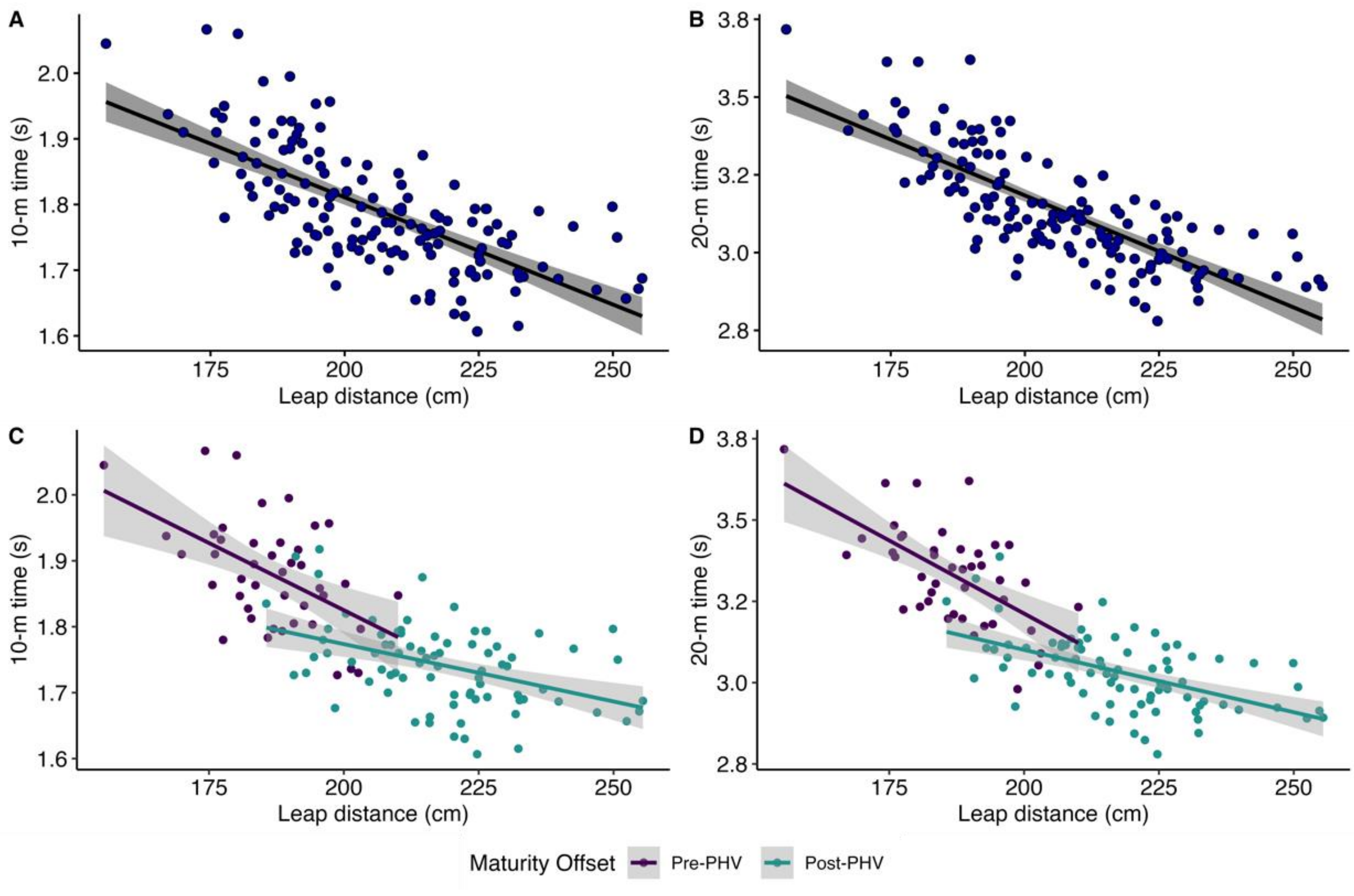

Figure 1: Between-player leap-for-distance and sprint 10 m (A) and 20 m (B) relationships (mean of repeated measures), including via maturity offset stratification (C, D). The grey area in the graph represents the 95% confidence bands of the regression line. For clarity, x and y standard deviation bars about each data point are not shown.

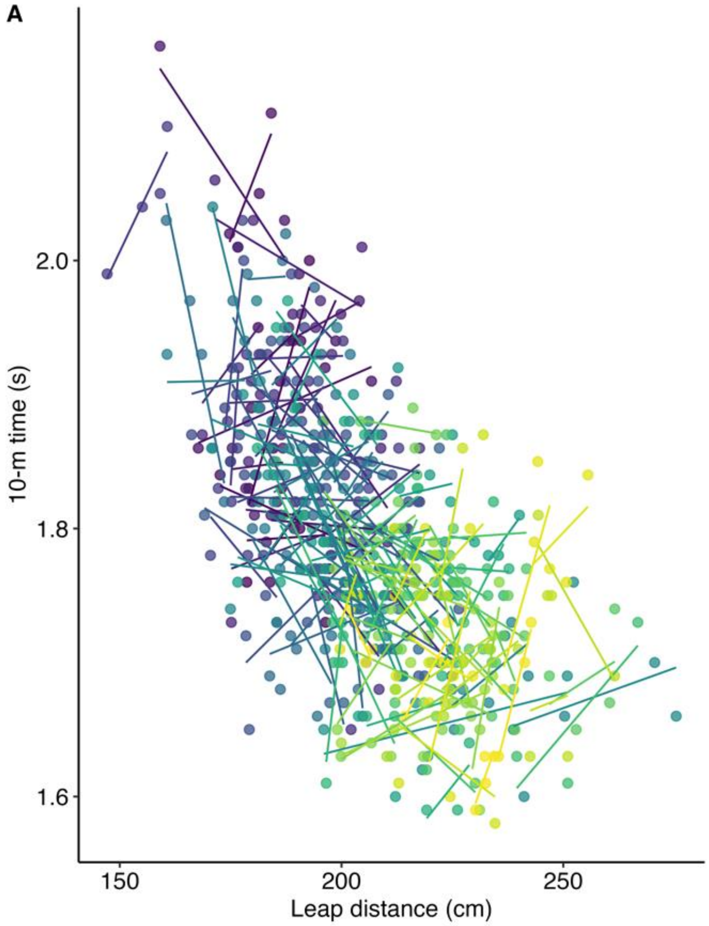

Figure 2: Within-player leap-for-distance and sprint relationships 10 m (A) and 20 m (B). Repeated measures within-player correlation; observations from the same player are given the same colour, with corresponding lines to show the slope for each player.

The between-player mean of repeated measures correlation coefficients for leap-for-distance against 10 m sprint time were large and moderate for pre-PHV and post-PHV respectively (r = -0.52, 95% CI [-0.71, -0.26]; r = -0.43, 95% CI [-0.60, -0.24], respectively), and large for leap-for-distance against 20 m for both pre-PHV and post-PHV (r = -0.62, 95% CI [-0.78, -0.39]; r = -0.54, 95% CI [-0.68, -0.36]). The negative correlations with both distances and maturation groups are visible in Figure 1C and 1D. The within-player correlation coefficients of leap-for-distance for pre-PHV against 10 m and 20 m times were small (r = -0.19, 95% CI [-0.35, -0.04]; r = -0.23, 95% CI [-0.38, -0.10]). The within-player correlation coefficients of leap-for-distance for post-PHV against 10 m and 20 m were trivial to small (r = -0.08, 95% CI [-0.22, 0.02]; r = -0.20, 95% CI [-0.34, -0.08]). The lack of substantial within-player relationships by maturation is visible from the diverse directions of the individual slopes in Figure 3. Similar to the total sample, individual players had both negative as well as positive correlations between the leap-for-distance and sprint values (10 m, 20 m): ranging across the entire correlation spectrum in both the pre-PHV and post-PHV group (i.e., r range between -1.0 to 1.0).

The differences (pre-PHV minus post-PHV) in mean correlation coefficients between maturation groups were as follows: between-players; leap-for-distance vs. 10 m = rdif -0.09 (-0.38 to 0.20), leap-for-distance vs. 20 m = -0.08 (-0.33 to 0.17), within-players; leap-for-distance vs. 10 m = -0.11 (-0.48 to 0.26), leap-for-distance vs. 20 m = -0.03 (-0.39 to 0.33). The majority of the point estimates for the difference between groups were below the pre-defined smallest practically important difference (± 0.1). However, the 95% CIs included meaningful small-moderate differences in both between-player and within-player relationships, demonstrating that the groups are not practically equivalent.

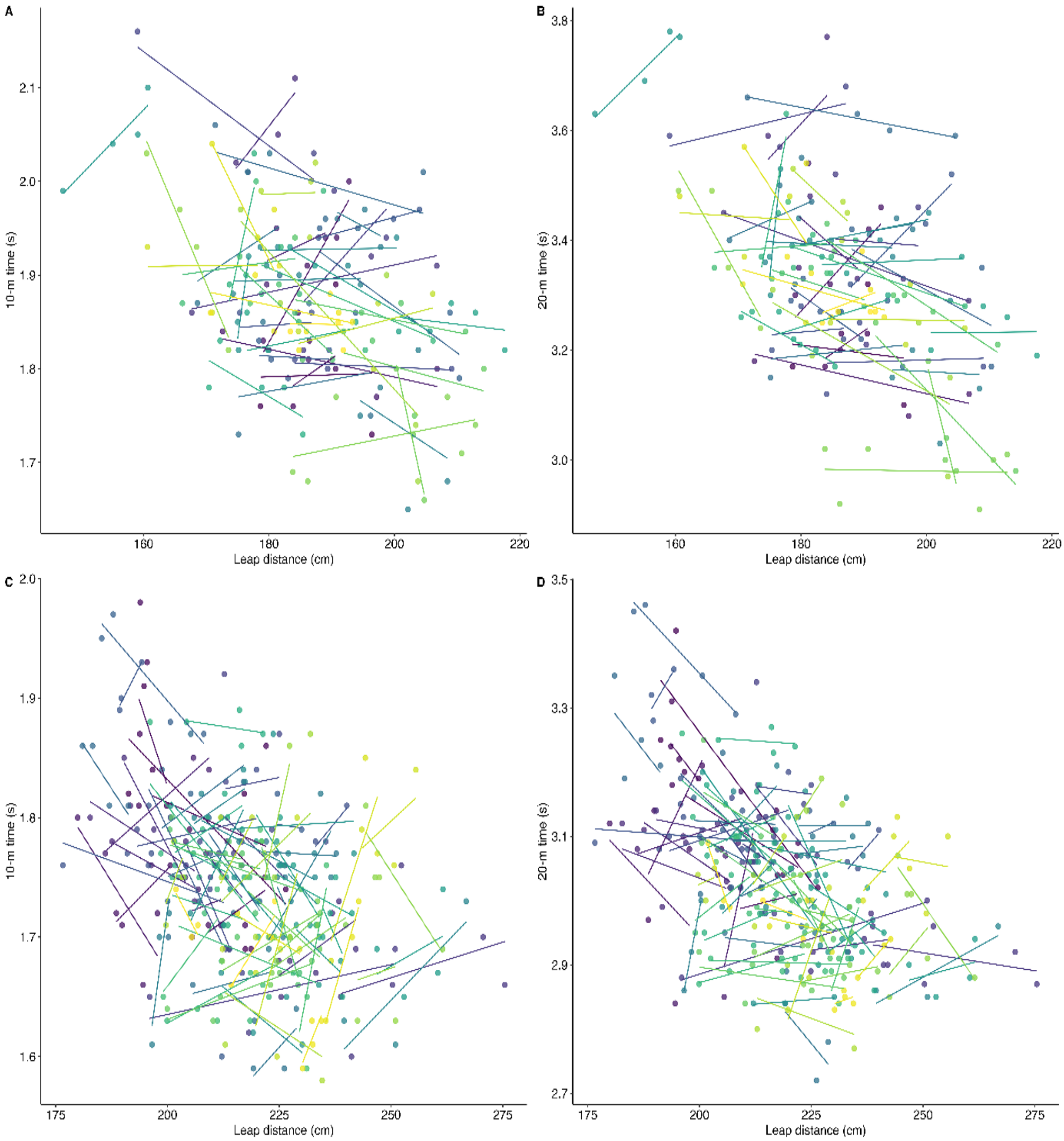

Figure 3: Within-player leap-for-distance and sprint relationships stratified via maturity offset from peak height velocity (PHV) with 10 m pre-PHV (A), post-PHV (C) and 20 m pre-PHV (B) and post-PHV (D). Repeated measures within-player correlation; observations from the same player are given the same colour, with corresponding lines to show the slope for each player.

4. Discussion

This is the first study to investigate longitudinal, within-player sprint performance changes in relation to a leap-for-distance measure in young male soccer players. The results of this study support the first hypothesis by showing clear associations between leap-for-distance and short sprint performance, both pre- and post-PHV. This suggests that in similar young male soccer cohorts, the leap-for-distance test would be useful for discriminating sprint ability between players. However, the second hypothesis was not accepted as within-player changes in leap-for-distance did not track changes in sprint performance over the duration of testing, irrespective of maturation. These findings therefore confirm that the leap-for-distance test is not a good proxy measure for monitoring changes in an individual's sprint performance over time.

Overall, very large negative associations (between-players) were observed for mean distance in the leap-for-distance test and mean sprint time (Figure 1A, 1B). This indicated that players who had greater distance covered during the leap-for-distance test also had faster sprint times. These results can be explained by the biomechanical similarities between the leap-for-distance and short sprint speed (Lockie et al., 2013; Morin et al., 2015). Similarities also exist between the movement patterns of the leap-for-distance and short sprint speed (i.e., cyclical, reciprocal movement). The findings are consistent with previous research demonstrating that players with high dynamic movement scores (jump) also have faster sprint times (McFarland et al., 2016). The study results demonstrated that this relationship holds over a long time period.

From the findings it was clear that the leap-for-distance length was not appropriate for predicting changes in the sprint times within young players, irrespective of the short sprint distance. Whilst small mean within-player negative relationships existed between the leap-for-distance and sprints, there was a wide range in the within-player individual relationships. A strong positive relationship (greater leap-for-distance length associated with increased [slower] sprint time) was observed in some players, a strong negative relationship in others and in some the relationship was trivial. This finding confirms that changes in the within-player leap-for-distance score are not associated with a change in the sprint times. Originally, it was planned to apply a linear mixed model with repeated sprint times as the outcome variable, and leap-for-distance scores as the predictor. However, the within-player correlation analysis revealed no substantial overall relationship, and so further analysis of the type conducted by Goosey-Tolfrey et al. (2020) was not considered instructive.

There might be several reasons why the leap-for-distance test was not a good predictor of sprint times within players over time in this study. One of the reasons could be the prevalence of long-term random error or 'noise' from the leap-for-distance and sprint testing. The reported short-term testing 'noise' in the leap-for-distance test was 2.1% (Laas et al., 2021), 1.7% in 10 m sprint and 1.4% in 20 m sprint in academy soccer players (Enright et al., 2018). Longitudinal 'noise' in the tests among young male soccer players has not been established yet on either of these variables. Given the high inter-player variability in the within-player correlation across different time points in this study, it is conceivable that the longitudinal 'noise' was bigger than the biological change in the sprints. Sprinting is a complex movement and the success in early phase sprint performance (< 20 m) is dependent on several aspects: horizontal and vertical force application (Lockie et al., 2013; Morin et al., 2015), increased stride frequency (Murphy et al., 2003), shorter contact time (Lockie et al., 2013; Murphy et al., 2003), increased stride length, and longer flight time (Lockie et al., 2013). Inconsistency in any of these elements over repeated measures could have influenced the players` sprint times, potentially adding more 'noise' to the test. Other factors that could have added to the noise associated with the tests were the environmental changes for the sprint (Haugen & Buchheit, 2016), which were a limitation and not possible to control in this study.

The comparison with maturation revealed large and moderate negative between-player correlations for the pre-PHV and post-PHV group between the leap-for-distance and sprint tests. The between-player mean correlation values were compared between maturation groups against a small practically important difference (rdif < 0.10). The 95% CIs for the difference between maturation groups included values beyond this threshold with both distances (10 m, 20 m), indicating that the groups were not practically equivalent and that meaningful differences could not be ruled out statistically. The maturation groups trivial between-player correlation point estimate differences (-0.09 and -0.08) were unexpected as more mature players have outperformed their less mature counterparts in previous research with power and speed activities (Mendez-Villanueva et al., 2011; Murtagh et al., 2018), which would have predicted a stronger negative relationship between the leap-for-distance and sprints in the post-PHV group. The within-player relationships between maturation groups were trivial to small ($r < -0.30$) and the CIs for the difference ranged over the set small important difference threshold with both distances, indicating no clear equivalence between the groups. These findings confirm that maturation did not have a significant impact on the leap-for-distance score and sprint times relationship, although low magnitude correlation between-group differences might exist.

The limitations of the study include the wide CIs of the leap-for-distance test using the AMAT system despite the high reliability (Laas et al., 2021), increasing the potential imprecision of the test with repeated measures. Secondly, the applied nature of the study meant that it was not possible to stringently control the test-to-test time periods due to practical factors. These included a lack of availability of the motion tracking system in the clubs or the players being unavailable for testing. Despite this, the test-to-test period was quite consistent (mean 4.4 ± 1.7 months). Lastly, the method of determining biological age via maturity offset has been associated with an error of six months in boys (Mirwald et al., 2002). The latter method is a non-invasive way of assessing maturation in applied settings, which has been successfully used to differentiate maturation status with large groups of young male soccer players (Portas et al., 2016; Towlson et al., 2018).

The study findings suggest that practitioners should not use the leap-for-distance test as a proxy for sprint testing when tracking players over time. Instead, practitioners should consider the individual relationships between the leap-for-distance and sprint scores, which could determine the strength and conditioning strategies that would be suitable for the players` physical development. To optimize individual physical development, the faster players with low leap-for-distance scores could undertake more high force (strength training) and higher leap-for-distance scores with slow sprint times more high velocity based (ballistic) training (Turner et al., 2021). These assumptions are based on previous recommendations to use jump and short sprint test scores to individualise training and enhance the players` physical profiles (Taylor et al., 2022). Furthermore, if practitioners do not have access to technology for accurately assessing sprint times, a leap-for-distance test might be a useful alternative for identifying quicker and slower players, but this relationship will be weaker when comparing within maturity groups.

5. Conclusion

The results from this study showed that the leap-for-distance test was a good discriminator of short sprint performance between young soccer players. However, the leap-for-distance test was not a good predictor of within-player changes in sprint performance over a longer time period in young soccer players and should not be used as a proxy measure to make intra-athlete speed inferences over short distances. The findings also indicated that sprint distance and maturation did not make a substantial difference in the within-player leap-for-distance and sprint relationships.

Conflict of Interest

The authors declare no conflict of interests.

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References

Bakdash, J. Z., & Marusich, L. R. (2017). Repeated measures correlation. *Frontiers in Psychology*, *8*, 456–456. https://doi.org/10.3389/fpsyg.2017.00456

Bland, J. M., & Altman, D. G. (1995a). Statistics notes: Calculating correlation coefficients with repeated observations: Part 1—correlation within subjects. *BMJ: British Medical Journal*, *310*(6977), 446–446. https://doi.org/10.1136/bmj.310.6977.446

Bland, J. M., & Altman, D. G. (1995b). Statistics notes: Calculating correlation coefficients with repeated observations: Part 2—correlation between subjects. *BMJ: British Medical Journal*, *310*(6980), 633–633. https://doi.org/10.1136/bmj.310.6980.633

Di Salvo, V., Baron, R., Gonzalez-Haro, C., Gormasz, C., Pigozzi, F., & Bachl, N. (2010). Sprinting analysis of elite soccer players during European Champions League and UEFA cup matches. *Journal of Sports Sciences*, *28*(14), 1489–1494. https://doi.org/10.1080/02640414.2010.521166

Enright, K., Morton, J., Iga, J., Lothian, D., Roberts, S., & Drust, B. (2018). Reliability of "in-season" fitness assessments in youth elite soccer players: A working model for practitioners and coaches. *Science and Medicine in Football*, *2*(3), 177–183. https://doi.org/10.1080/24733938.2017.1411603

Faude, O., Koch, T., & Meyer, T. (2012). Straight sprinting is the most frequent action in goal situations in professional football. *Journal of Sports Sciences*, *30*(7), 625–631. https://doi.org/10.1080/02640414.2012.665940

Gathercole, R. J., Sporer, B. C., Stellingwerff, T., & Sleivert, G. G. (2015). Comparison of the capacity of different jump and sprint field tests to detect neuromuscular fatigue. *Journal of Strength and Conditioning Research*, *29*(9), 2522–2531. https://doi.org/10.1519/JSC.0000000000000912

Goosey-Tolfrey, V., Totosy de Zepetnek, J., Keil, M., Brooke-Wavell, K., & Batterham, A. M. (2020). Tracking within-athlete changes in whole body fat percentage in wheelchair athletes. *International Journal of Sports Physiology and Performance*, *16*(1), 1–6. https://doi.org/10.1123/ijspp.2019-0867

Haugen, T., & Buchheit, M. (2016). Sprint running performance monitoring: Methodological and practical considerations. *Sports Medicine (Auckland)*, *46*(5), 641–656. https://doi.org/10.1007/s40279-015-0446-0

Haugen, T., Tønnessen, E., Hisdal, J., & Seiler, S. (2014). The role and development of sprinting speed in soccer. *International Journal of Sports Physiology and Performance*, *9*(3), 432–441. https://doi.org/10.1123/IJSPP.2013-0121

Holm, D. J., Stålbom, M., Keogh, J. W., & Cronin, J. (2008). Relationship between the kinetics and kinematics of a unilateral horizontal drop jump to sprint performance. *Journal of Strength and Conditioning Research*, *22*(5), 1589–1596. https://doi.org/10.1519/JSC.0b013e318181a297

Hopkins, W. G. (2006). A spreadsheet for combining outcomes from several subject groups. *Sportscience*, *10*, 51–53.

Hopkins, W. G., Marshall, S. W., Batterham, A. M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine and Science in Sports and Exercise*, *41*(1), 3–12. https://doi.org/10.1249/MSS.0b013e31818cb278

Hulteen, R. M., Morgan, P. J., Barnett, L. M., Stodden, D. F., & Lubans, D. R. (2018). Development of foundational movement skills: A conceptual model for physical activity across the lifespan. *Sports Medicine (Auckland)*, *48*(7), 1533–1540. https://doi.org/10.1007/s40279-018-0892-6

Juris, P. M., Phillips, E. M., Dalpe, C., Edwards, C., Gotlin, R. S., & Kane, D. J. (1997). A dynamic test of lower extremity function following anterior cruciate ligament reconstruction and rehabilitation. *The Journal of Orthopaedic and Sports Physical Therapy*, *26*(4), 184–191. https://doi.org/10.2519/jospt.1997.26.4.184

Laas, M. M., Wright, M. D., McLaren, S. J., Eaves, D. L., Parkin, G., & Portas, M. D. (2020). Motion tracking in young male football players: A preliminary study of within-session movement reliability. *Science and Medicine in Football*, *4*(6), 203–210. https://doi.org/10.1080/24733938.2020.1737329

Laas, M. M., Wright, M. D., McLaren, S. J., Portas, M. D., Parkin, G., & Eaves, D. L. (2021). Between-week reliability of motion tracking screening: A preliminary study with youth male football players. *European Journal of Human Movement*, *46*, 59–65. https://doi.org/10.21134/eurjhm.2021.46.11

Lockie, R. G., Murphy, A. J., Schultz, A. B., Jeffriess, M. D., & Callaghan, S. J. (2013). Influence of sprint acceleration stance kinetics on velocity and step kinematics in field sport athletes. *Journal of Strength and Conditioning Research*, *27*(9), 2494–2503. https://doi.org/10.1519/JSC.0b013e31827f5103

Malcata, R. M., Vandenbogaerde, T. J., & Hopkins, W. G. (2014). Using athletes' world rankings to assess countries' performance. *International Journal of Sports Physiology and Performance*, *9*(1), 133–138. https://doi.org/10.1123/ijspp.2013-0014

McFarland, I. T., Dawes, J. J., Elder, C. L., & Lockie, R. G. (2016). Relationship of two vertical jumping tests to sprint and change of direction speed among male and female collegiate soccer players. *Sports (Basel, Switzerland)*, *4*(1), 11. https://doi.org/10.3390/sports4010011

Mendez-Villanueva, A., Buchheit, M., Kuitunen, S., Douglas, A., Peltola, E., & Bourdon, P. (2011). Age-related differences in acceleration, maximum running speed, and repeated-sprint performance in young soccer players. *Journal of Sports Sciences*, *29*(5), 477–484. https://doi.org/10.1080/02640414.2010.536248

Mirwald, R. L., Baxter-Jones, A. D. G., Bailey, D. A., & Beunen, G. P. (2002). An assessment of maturity from anthropometric measurements. *Medicine and Science in Sports and Exercise*, *34*(4), 689–694. https://doi.org/10.1097/00005768-200204000-00020

Morin, J. B., Slawinski, J., Dorel, S., de villareal, E. S., Couturier, A., Samozino, P., Brughelli, M., & Rabita, G. (2015). Acceleration capability in elite sprinters and ground impulse: Push more, brake less? *Journal of Biomechanics*, *48*(12), 3149–3154. https://doi.org/10.1016/j.jbiomech.2015.07.009

Murphy, A. J., Lockie, R. G., & Coutts, A. J. (2003). Kinematic determinants of early acceleration in field sport athletes. *Journal of Sports Science and Medicine*, *2*(4), 144–150.

Murtagh, C. F., Brownlee, T. E., O'Boyle, A., Morgans, R., Drust, B., & Erskine, R. M. (2018). Importance of speed and power in elite youth soccer depends on maturation status. *Journal of Strength and Conditioning Research*, *32*(2), 297–303. https://doi.org/10.1519/JSC.0000000000002367

Nicholson, B., Dinsdale, A., Jones, B., & Till, K. (2021). The training of short distance sprint performance in football code athletes: A systematic review and meta-analysis. *Sports Medicine (Auckland)*, *51*(6), 1179–1207. https://doi.org/10.1007/s40279-020-01372-y

Oliver, J. L., Lloyd, R. S., & Rumpf, M. C. (2013). Developing speed throughout childhood and adolescence: The role of growth, maturation and training. *Strength and Conditioning Journal*, *35*(3), 42–48. https://doi.org/10.1519/SSC.0b013e3182919d32

Philippaerts, R. M., Vaeyens, R., Janssens, M., Van Renterghem, B., Matthys, D., Craen, R., & Malina, R. M. (2006). The relationship between peak height velocity and physical performance in youth soccer players. *Journal of Sports Sciences*, *24*(3), 221–230. https://doi.org/10.1080/02640410500189371

Portas, M. D., Parkin, G., Roberts, J., & Batterham, A. M. (2016). Maturational effect on Functional Movement Screen™ score in adolescent soccer players. *Journal of Science and Medicine in Sport*, *19*(10), 854–858. https://doi.org/10.1016/j.jsams.2015.12.001

Small, K., McNaughton, L. R., Greig, M., Lohkamp, M., & Lovell, R. (2009). Soccer fatigue, sprinting and hamstring injury risk. *International Journal of Sports Medicine*, *30*(8), 573–578. https://doi.org/10.1055/s-0029-1202822

Taylor, J. M., Cunningham, L., Hood, P., Thorne, B., Irvin, G., & Weston, M. (2019). The reliability of a modified 505 test and change-of-direction deficit time in elite youth football players. *Science and Medicine in Football*, *3*(2), 157–162. https://doi.org/10.1080/24733938.2018.1526402

Taylor, J. M., Madden, J. L., Cunningham, L. P., & Wright, M. (2022). Fitness testing in soccer revisited: Developing a contemporary testing battery. *Strength and Conditioning Journal*, *44*(5), 10–21. https://doi.org/10.1519/SSC.0000000000000702

Towlson, C., Cobley, S., Parkin, G., & Lovell, R. (2018). When does the influence of maturation on anthropometric and physical fitness characteristics increase and subside? *Scandinavian Journal of Medicine & Science in Sports*, *28*(8), 1946–1955. https://doi.org/10.1111/sms.13198

Turner, A. N., Comfort, P., McMahon, J., Bishop, C., Chavda, S., Read, P., Mundy, P., & Lake, J. (2021). Developing powerful athletes part 2: Practical applications. *Strength and Conditioning Journal*, *43*(1), 23–31. https://doi.org/10.1519/SSC.0000000000000544

Unnithan, V., White, J., Georgiou, A., Iga, J., & Drust, B. (2012). Talent identification in youth soccer. *Journal of Sports Sciences*, *30*(15), 1719–1726. https://doi.org/10.1080/02640414.2012.731515

Wijnbergen, M. (2019). *Novel algorithms to capture kinematic variables with depth-sensing technology. The development of a reliable, valid and practical movement assessment tool* [Doctoral dissertation, Teesside University]. Teesside University's Research Portal. https://research.tees.ac.uk/ws/portalfiles/portal/25374496/Thesis_MarkWijnbergen.pdf

Williams, C. A., Oliver, J. L., & Faulkner, J. (2011). Seasonal monitoring of sprint and jump performance in a soccer youth academy. *International Journal of Sports Physiology and Performance*, *6*(2), 264–275. https://doi.org/10.1123/ijspp.6.2.264

Wright, M. D., & Atkinson, G. (2019). Changes in sprint-related outcomes during a period of systematic training in a girls' soccer academy. *Journal of Strength and Conditioning Research*, *33*(3), 793–800. https://doi.org/10.1519/JSC.0000000000002055

Wrigley, R. D., Drust, B., Stratton, G., Atkinson, G., & Gregson, W. (2014). Long-term soccer-specific training enhances the rate of physical development of academy soccer players independent of maturation status. *International Journal of Sports Medicine*, *35*(13), 1090–1094. https://doi.org/10.1055/s-0034-1375616