PHYSICAL CHARACTERISTICS OF ELITE YOUTH FEMALE SOCCER PLAYERS CHARACTERISED BY MATURITY STATUS

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Running Head: Female Soccer Physical Characteristics

ABSTRACT

The purpose of this study was to investigate the influence of maturity status on the physical characteristics of youth female soccer players. 157 players from 3 elite soccer academies In England completed assessments of anthropometry, strength (isometric mid-thigh pull; IMTP), lower body power (countermovement jump; CMJ), aerobic capacity (YYIRL1), change of direction (CoD: 505-left/right), and speed (10 and 30 m). Each player was classified into 1 of 6 maturity groups based on their estimated years from peak height velocity (YPHV). Magnitude based-inferences were used to assess for practical significance between consecutive groups. Speed, CoD time, CMJ and aerobic capacity were all *possibly-most likely* better in more mature players. However, there was a *likely* difference in relative peak force (PF) between maturity groups -0.5 YPHV (27.13 ± 4.24 N·Kg^{-1}) and 0.5 YPHV (24.62 ± 3.70 N·Kg^{-1}), which was associated with a *likely* difference in 10 m sprint time (-0.5 YPHV: 2.00 ± 0.12s vs. 0.5 YPHV 2.08 ± 0.16s) and *unclear* changes in CMJ and CoD time. Findings provide novel comparative data for this cohort relative to maturity status and can be used by strength and conditioning coaches to inform the design of training programs for youth female soccer players. Strength and conditioning coaches should be aware that youth female soccer players may experience a decrease in relative strength around PHV, which may impact upon the speed, CoD time and CMJ of players.

Key words: maturation, talent development, fitness testing

INTRODUCTION

In recent years female soccer has grown rapidly, with an exponential rise in the number of opportunities to play professionally and also increased youth participation worldwide (33). To support this growth in female soccer, the Football Association (FA) in England have created elite Regional Talent Centre's (RTC's) for the identification and development of talented youth female soccer players, similar to the processes in the men's game (e.g., English Player Performance Plan; EPPP; 29). The RTC's operate within youth age categories (i.e., Under 10 [U10], U12, U14 and U16), whereby girls are selected to train and compete within an academy environment. The aim is to develop youth female players technically, tactically, psychologically and physically to prepare them for the elite senior game (6).

Currently there is limited research describing the physical characteristics of youth female soccer players, thus comparative data are limited for S&C coaches working with youth players to subsequently profile players against players beyond those within their club (10). To the authors' knowledge only three studies have explored the physical characteristics of youth female soccer players in England (10, 33, 36). However, the studies by Taylor et al. (33) and Wright et al. (36) and were conducted prior to the restructuring of the girls' soccer academies in England and therefore do not reflect the current age group structuring, making comparisons difficult for current practitioners in the field. Furthermore, these data were based on one academy with a small sample size (U13; n=10 and U15; n=9 (33) n=14 players (36)) and one study only reported data by chronological age (33). Emmonds et al. (10) did consider the influence of both age and maturation on the strength characteristics of youth female soccer players, however little is known about the influence of maturation on other physical qualities such as lower body power, change of direction and aerobic capacity, which are all important for soccer performance (6).

Research in male youth soccer (26, 31) has demonstrated the influence of maturation status on physical performance of youth players, suggesting that it may be more appropriate to consider youth athletes by maturity status instead of traditional chronological annual-age groupings (17). If S&C coaches working with elite youth female soccer players are to use physical testing data to make informed decisions about the 'athleticism' of players and to inform training program design, it is important that S&C coaches are aware of the impact maturation may have on the development of specific physical qualities. While there has been a large body of research exploring the influence of maturation on the physical development of youth male soccer players (4, 18, 19, 26, 31) extrapolating male youth data and applying it to females may be erroneous given the different physiological and morphological changes that occur in males and females during maturation (3). Therefore, there is a need for further research specific to female youth soccer players that considers the influence of maturity status on physical qualities. This will allow S&C coaches and other practitioners working with youth female players to make more informed decisions about a player's physical performance in relation to their stage of development. Therefore, the purpose of the study was to evaluate the influence of maturity status on the physical characteristics of elite youth female soccer players. Such findings will help S&C coaches better understand the influence of maturation on the development of physical characteristics in young female athletes. Such findings can be then used to inform the design of individualised S&C program that are relevant to the individual stages of biological development, rather than based on the chronological age.

METHODS

Experimental Approach to the Problem

A cross-sectional study design was conducted to investigate the influence of maturity status on the physical characteristics of elite youth female soccer players. All subjects undertook assessments of anthropometry and completed a physical testing battery at the start of the 2016-2017 season (i.e., September, at the end of preseason). Testing was conducted a minimum of 48 hours post competitive match play or training at each respective RTC. A standardised warm-up, including jogging and dynamic movements for 10-mins followed by jumps and sprints of progressive intensity for 5-mins were undertaken prior to testing. This was then followed by full instruction and demonstrations of the assessments. The lead researcher undertook all testing.

Anthropometry assessments included stature, sitting height and body mass. The testing battery included assessments of strength (isometric mid-thigh pull; IMTP) on a portable force plate, lower body power (countermovement jump; CMJ), aerobic capacity (Yo-Yo intermittent recovery test level 1 (YYIRL1)), speed (10 and 30 m) and change of direction (CoD 505 test left and right). The YYIRL1 was not conducted at the U10 age category, as this was not current practice at the RTC's.

Subjects

157 female soccer players (U10, *n*=30; U12, *n*=38, U14, *n*=43, U16, *n*=46) were recruited from three elite Tier 1 female soccer RTC's in England. Age categories were defined by

chronological age on the 1st September 2016, which established their status for competition. All subjects were free from injury at the time of the study. U10 and U12 age categories trained twice per week (2 x 90 min pitch based sessions and 1 x 60-min S&C session, which included gym and field based sessions) and U14 and U16 age categories trained three times per week (3 x 90 min based sessions and 2 x 60-min S&C sessions), with each age group having on average 20 matches over a 35-week season.

U10 and U12 age categories trained twice per week (2 x 90 min pitched based sessions and 1 x 30-min strength and conditioning session) and U14 and U16 age categories trained three times per week (3 x 90 min based sessions and 2 x 60-min strength and conditioning session), with each age group having on average 20 matches over a 35-week season. The maturation groups were determined by the predicted years from peak height velocity (PHV) derived from anthropometric assessments (27). Prior to participating in the study, institutional ethics approval was granted from the Research Ethics Committee. Parental consent and subject ascent were obtained prior to commencing the study.

Procedures

Anthropometric Measurements and Maturity Status:

Standing height, sitting height and leg length were determined using previous methods descried by Malina and Koziel (21). For the assessment of standing height, subjects were stood in an erect posture with weight evenly distributed between both feet, heels together, arms hanging relaxed at the sides and the head in the Frankfurt horizontal plane. Standing height was measured to the nearest 0.1cm. Sitting height was also measured to the nearest 0.1cm with the distance from a flat sitting surface (40 cm high) to the top of the head taken as the measurement. Subjects sat in standard erect posture with the head in the Frankfurt horizontal plane; knees were together and directed straight ahead. Subjects were dressed in shorts and t-shirt with trainers removed for the assessment of body mass. Body mass was measured to the neared 0.1 kg.

Maturity was estimated from anthropometric measurements using the protocol proposed by Mirwald et al. (27) equation (Equation 1) in which stature, sitting height, leg length, chronological age and the interaction between these variables are used in order to predict the number of years from PHV (YPHV, maturity offset). While some studies have questioned the use of this method (20, 22), this method was chosen due to the non-invasive nature of the assessment and the satisfactory levels of measurement accuracy (27). The equation has been reported to be a reliable (R^2= 0.91, SEE=0.50), non-invasive practical solution for the measure of biological maturity for matching adolescent athletes (27) and has previously used for the assessment of maturation in youth female soccer in previous research (36). YPHV was calculated for each subject by subtracting the age at PHV from chronological age.

Maturity Offset = -16.364 + 0.0002309 x leg length and sitting height interaction + 0.006277 x age and sitting height interaction + 0.179 x leg by height ratio + 0.0009428 x age and weight interaction.

Equation 1.

Each subject was categorized into 1 of 6 maturity-offset groups (i.e., -2.5 YPHV [≤ 2.0], -1.5 YPHV [-1.99 to -1.0], -0.5 YPHV [-0.99 to 0.0], 0.5 YPHV [0.01 to 1.0], 1.5 YPHV [1.01

to 2.0], and 2.5 YPHV [≥ 2.01]). These categories were consistent with previous categories used in the literature to define maturity status (23).

Strength:

The IMTP was performed on a commercially available portable force platform (AMTI, ACP, Watertown, MA) with a sampling rate of 1000Hz, which is consistent with previous methodologies (9). Subjects performed the IMTP on a customized pull rack, using a self-selected position similar to that of the second pull of a power clean, with a flat trunk position and their shoulders in line with the bar (12). The self-selected mid-thigh position was preferred, as differences in knee and hip joint angles during the IMTP have previously been shown to have no influence on kinetic variables (5). Subjects were given two practice trials prior to testing commencing. Subjects were instructed to pull as "fast and hard" as possible, and received loud, verbal encouragement (9). Each subject completed two trials lasting five seconds, with five mins rest between each trial. The highest PF achieved over the two trials was considered the subjects 'best trial.' PF was identified as the maximum force value obtained during the best trial of the IMTP. PF intraclass correlation (ICC) and coefficient of variation (CV) PF were $r = 0.93$, CV = 3.6%. In addition to highest PF, relative PF was calculated using the ratio scaling method (i.e. PF / body mass) (14).

Lower Body Power:

Lower body power was assessed using a CMJ in an indoor gym facility that provided a consistent stable flooring to minimize the influence of external factors (e.g., weather, foot-surface interaction) and were allowed 2-mins recovery between jumps. The CMJs were performed according to previously described methods (30) using a portable photoelectric cell system (Optojump; Microgate, Bolzano, Italy). This equipment has been reported as both reliable and valid (CV = 6%, SEE = 1%) for vertical jump assessment compared with a biomechanical force plate (11). Jump height was calculated using the cell system software (Optojump Next v1.7.9; Microgate). Subjects completed 3 submaximal CMJ efforts prior to testing commencing. The CMJ started from an upright position. When given a verbal command, the subjects made the downward countermovement to their preferred depth and then jumped as high as possible. Subjects were required to keep their legs straight during the airborne phase of the jump. The highest jump was selected for analysis. ICC and CV for CMJ were r = 0.96, CV = 4.5%.

Aerobic Capacity:

Aerobic capacity was assessed using the YYIR1. The YYIR1 was selected as it has been reported as a valid and reliable test (r = 0.98, CV = 4.9%) for the assessment of soccer specific fitness (15). The test consisted of repeated 20 m shuttle runs at progressively increasing speeds dictated by an audio bleep emitted from a CD player. Between each shuttle a recovery period of 10 seconds is allowed involving walking around a marker placed 5 m behind the finishing line. Failure to achieve the shuttle run in time on two occasions resulted in termination of the test. The final level achieved and total running distances were recorded.

Change of Direction (CoD) Time:

CoD was assessed using the 505 test, whereby the subjects were positioned 15 m from a turning point. Timing gates (Brower Timing Systems, IR Emit, USA). were placed 10 m from the start point and 5 m from the turn point. Subjects accelerated from the start through the timing gates, turning 180^0 at the 15 m mark and sprinted back through the timing gates. Subjects completed 3 alternate attempts on each foot (i.e., right and left leg), separated by a 2–3 minute rest period. Only attempts whereby the subjects' foot crossed the 15 m mark were included. Times were recorded to the nearest 0.01 sec with the quickest of the 3 attempts used as the final score. Data are presented as dominant (D) or non-dominant (ND) foot based on preferred kicking foot. ICC and CV for the 505 test were r = 0.995, CV = 2.2%.

Sprint time:

Sprint times were assessed over 10 m and 30 m using timing gates (Brower Timing Systems, IR Emit, USA). Subjects started 0.5 m behind the initial timing gate and were instructed to set off in their own time and run maximally past the 30 m timing gate. Each subject had 3 attempts, separated by a 3-minute rest period. Times were recorded to the nearest 0.01 seconds with the quickest of the three attempts used for the sprint score. ICC and CV's for 10 and 30 m sprint time were r = 0.76, CV = 4.8% and r = 0.78, CV = 3.9%, respectively.

Statistical Analyses

Data are presented as mean ± SDs by maturity status. All data were log transformed to reduce bias as a result of non-uniformity error. Magnitude based-inferences were used to assess for practical significance between consecutive maturity groups for each variable (13). The threshold for a difference to be considered practically important (the smallest worthwhile difference; SWD) was set at 0.2 x between subject SD for the comparison groups, based on Cohen's *d* effect size (ES) principle. The probability that the magnitude of difference was greater than the SWD was rated as <0.5%, *almost* *certainly not*; 0.5-5%, *very unlikely*; 5-25%, *unlikely*; 25-75%, *possibly*; 75-95%, *likely*; 95-99.5%, *very likely*; >99.5%, *almost certainly* (16). ES were rated as *trivial* (<0.2), *small* (0.2<0.6), *moderate* (0.6<1.2) *large* (1.2<2.0) or *very large* (2.0<4.0) (14). Where the 90% Confidence Interval (CI) crossed both the upper and lower boundaries of the SWD (ES±0.2), the magnitude of difference was described as *unclear* (13).

RESULTS

The anthropometric and physical characteristics of elite youth female soccer players by maturity status are presented in Table 1 and the standardized differences for anthropometric and physical characteristics between consecutive maturation groups are shown in Table 2. Stature and sitting height were *very likely to most likely* greater in more mature players*. Likely to most likely* differences in leg length were observed in consecutive maturity groups until 0.5 YPHV, with only *possibly* differences observed between consecutive maturity groups post-PHV. *Likely to most likely* differences in body mass were observed between consecutive maturity groups, with more mature players being heavier than less mature players

Insert Table 1 Near Here*

PF was *likely to most likely* greater for more mature players. However, differences in relative PF between consecutive maturity groups were *possibly small to possibly trivial,* except for between maturity groups -0.5 YPHV and 0.5 YPHV, where a *likely* difference was observed. There were *likely* differences in CMJ between consecutive maturity groups -2.5 to -0.5 YPHV but only *possibly small* differences between groups -0.5 and 0.5

YPHV were observed. *Most likely* differences in CMJ height were observed in maturity groups 1.5 YPHV – 2.5 YPHV. Both 10 and 30 m sprint times were lower in more mature players, with *possibly* to *most likely* differences observed between consecutive maturity groups until 1.5 YPHV. Differences in 10 and 30 m sprint times between the maturity groups 1.5 YPHV – 2.5 YPHV were *possibly trivial to possibly small*, respectively.

CoD time was less in more mature players with p*ossibly to very likely* differences observed between maturity groups, except for between maturity groups -0.5 YPHV – 0.5 YPHV, where differences between groups were *possibly trivial. Likely small* differences in distance covered on the YYIRL1 were observed between maturity groups 0.5 YPHV – -0.5 YPHV. All other differences between consecutive maturity groups were *possibly trivial*.

Insert Table 2 Near Here*

DISCUSSION

The aim of this study was to investigate the influence of maturation on the physical characteristics of youth female soccer players. Findings demonstrate that speed, CoD, lower body power and aerobic fitness were improved in more mature players. However, the development of physical characteristics was non-linear between consecutive maturation groups. S&C coaches need to consider the maturity status of youth female soccer players when evaluating physical testing data and consider the non-linear development of physical qualities. Such data can also be used as comparative data by S&C coaches working in youth female soccer when assessing the performance of their own players.

Differences in leg length between consecutive maturity groups were greatest between groups -2.5 – -0.5 YPHV. These findings are consistent with normal somatic growth, whereby peak leg length growth occurs just before PHV (17). The development of anthropometric characteristics with advancing maturity likely accounts for a number of observed changes in physical characteristics between consecutive maturity groups (19), therefore highlighting the importance of regularly assessing maturity status (approximately every 3 months, (17)).

PF was greater in more mature female soccer players, which may be attributed to biological changes associated with advanced maturity, including increased body mass (3). Furthermore, given more mature players were typically older, the greater PF may also be explained by an increased exposure to a structured S&C program within the academies at the older age groups (i.e. structured gym based resistance training at the U14 and U16 age categories twice per week for 60-mins). However, when made relative to body mass, relative PF did not increase linearly between consecutive maturity groups, highlighting the importance of considering relative versus absolute measures of PF. Greatest relative PF was observed in the maturity group -0.5 YPHV (0.99 to 0.0 YPHV), which may be related to hormonal and morphological changes (i.e. increase in muscle mass) reported to occur around PHV (3). These findings are consistent with previous longitudinal (7) and cross-sectional (2) strength assessment research for non-elite female athletes. A *likely moderate* difference in relative PF was observed between maturity groups -0.5 YPHV and 0.5 YPHV, with lower relative PF in the more mature players (0.5 YPHV). In line with this finding, there were also unclear changes in lower body power (CMJ height) between these respective maturity groups. Together these findings suggest that female soccer players may experience a reduction in relative PF and consequently lower body power at 0.5 YPHV [0.01 to 1.0 YPHV). This may be explained by a potential increase in fat mass associated with peak weight velocity (PWV), that occurs in females 3.5 to 10.5 months after PHV (3), which has a non-functional role for athletic performance. However, a limitation of this study was that it was not possible to obtain body composition data for players, therefore the reason for the observed differences is speculative and requires further research. Nonetheless, S&C coaches should be aware of this possible reduction in relative PF after PHV in youth female soccer players, given the known relationship between strength and athletic performance (32) and the relationship between low relative strength and increased risk of injury in children (8). Findings support the need for youth female soccer players to regularly undertake structured strength training as part of their training program, particularly after PHV.

Both 10 and 30 m sprint times were less in more mature players, indicating faster sprint times with advanced maturity. However, findings demonstrate that acceleration ability (10 m) and maximum speed (30 m) are unique physical qualities, which do not develop at the same rate between consecutive maturity groups. Greatest differences in 30 m sprint time between consecutive maturity groups was observed between -2.5 – 0.5 YPHV, with *very likely- likely* differences observed. This may be explained by the *very likely - most likely* differences in leg length between these respective groups, which has been reported in male youth athletes to account for improvements in stride length and thus sprint time (23). In contrast, 10 m sprint time may be influenced more by relative strength, improved running mechanics and neuromuscular control (24). Players -0.5 YPHV had faster 10 m sprint times than players 0.5 YPHV. As previously discussed, this was in line with a *likely moderate* difference in relative PF between these consecutive maturity groups, which may have had a negative influence on force production capabilities (25). Again, this supports the need for youth female soccer players to regularly undertake strength training as part of their weekly training schedule as strength development in addition to the development of correct movement patterns and neuromuscular control, underpins the development of other physical qualities (31).

This finding is in contrast to the findings of youth male soccer players who have been reported to display an improvement in sprint times after PHV (23). These differences may be due to the different physiological changes that occur in males and females with the onset of maturation, with males experiencing a greater increase in lean muscle mass which results in improved expression of both concentric strength and power (16). As previously discussed, an increase in body mass and fat mass in females after PHV may possibly explain why 10 m sprint times increased in the maturity group 0.5 YPHV. Therefore, coaches working with youth female soccer players who are -0.5 - 0.5 YPHV need to be aware that players may experience increases in sprint times during this period of development and consider this when evaluating the physical performance of players.

CoD times were less in more mature players, indicating more efficient CoD ability, however greatest differences between consecutive maturation groups were observed -2.5 - -1.0 YPHV (*likely – very likely*). Improvements in CoD time in players at this stage of maturation may be explained by improvements in neuromuscular control and co-ordination (8). Players at the U10 and U12 age groups included in this study, were regularly taking part in a structured S&C session each week, in addition to two field based soccer training sessions. Given that previous research has shown CoD time can be improved in less mature players using neuromuscular training (8), potentially this may have also facilitated improvements in neuromuscular control beyond the natural development of this physical attribute at this stage of development. Differences in CoD time between maturity groups circa-PHV (-0.5 – 0.5 YPHV) were *unclear.* Given that relative strength has previously been reported to be strongly correlated with CoD time in female athletes, the lower relative PF observed in females 0.5 YPHV in this study may explain why differences in CoD time at these maturity groups were *unclear*.

Distance covered on the YYIRL1 was greater for more mature players. *Likely* differences were observed between maturity groups -0.5 – 0.5 YPHV. This is consistent with findings for 8-16-year-old untrained youth females, where aerobic fitness was observed to be greatest around circa-PHV and decrease post-PHV (28). Previous research has reported that growth-related changes to the central and peripheral cardiovascular system, including increases in stroke volume and cardiac output, as well as changes in muscular function and metabolic capability occur around the onset of PHV (3). This may explain the *likely* differences in aerobic capacity observed between maturity groups -0.5 – 0.5 YPHV. Furthermore, research has shown that percentage body fat is an important factor in the variation of aerobic fitness of youth females (1, 28). Therefore, *unclear* differences in distance covered on the YYIRL1 test between maturity groups post-PHV in this study may be explained by a possible increase in fat mass at this stage of development. As such it is important that S&C coaches working with this cohort actively look to develop the aerobic capacity of youth female players post-PHV.

While this study provides S&C coaches with a better understanding of the influence of maturity status on the physical development of youth female athletes, it must be noted that this study is not without its limitations. Firstly, the estimation of maturation from somatic measures and predictive equations rather than using a measure of biological maturation likely results in some degree of error (20, 22), which coaches must consider when interpreting the data. Analysis of such data is further complicated by the different categories used in the literature to define maturity status. Given that players may not have all entered the RTC at the same age, a second limitation of the study was that it was not possible to obtain information on the training age of the players which may influence physical performance. Therefore, future research should also look to consider the training age of players in addition to other variables not evaluated in this study which may impact on physical performance (i.e. menstrual cycle, training loads). Finally, this study adopted a cross-sectional design, thus future studies should look to employ longitudinal designs to infer development trajectories as opposed to differences by maturation status.

Practical Applications

It is recommended that S&C coaches regularly monitor anthropometric variables to detect periods of rapid growth and maturation, which may impact upon the physical characteristics of youth female soccer players. S&C coaches need to be aware that relative PF may decrease following PHV, which may impact upon players lower body power, 10 m acceleration and CoD time. Therefore, coaches should consider a players' stage of biological age when evaluating physical testing scores or designing S&C programs in addition to other factors such as training age. Given the importance of strength for athletic performance (32), it is recommended that S&C coaches should look to improve neuromuscular strength and fundamental movement skills in players pre-PHV. These qualities can be developed by working on correct running mechanics, multi-planer jumping and landing tasks and sprinting as part of fun and engaging pitch based warm ups (35). Players circa-PHV may experience decreases in relative PF, therefore it is important S&C coaches focus on the development of strength during this period of development. However, it is important that coaches are aware that players at this stage may also experience a reduction in co-ordination, therefore the focus of resistance based exercises must first be on technique (35), which can be developed as part of structured gym based training sessions as well as continuing to develop running mechanics and jumping technique as part of pitch based training sessions. Players post-PHV may benefit from individualised gym and pitch based conditioning programmes. Furthermore, findings of this study suggest the coaches should look to actively develop the aerobic system in player's post-PHV. Manipulation of small-sided games combined with short duration intermittent high-intensity running drills may provide an efficient training stimulus whilst concurrently developing technical/tactical skills within the same session.

REFERENCES

1. Armstrong, N, and Welsman, J. Peak oxygen uptake in relation to growth and maturation in 11-to 17–year-old humans. Eur J Appl Physiol 85: 546-551, 2001.
2. Barber-Westin, SD, Noyes, FR, and Galloway, M. Jump-land characteristics and muscle strength development in young athletes: A gender comparison of 1140 athletes 9 to 17 years of age. Am J Sports Med 34: 375-384, 2006.
3. Baxter-Jones, AD, and Sherar LB. Growth and maturation. In: Paediatric Exercise Physiology. N Armstrong, ed. Philadelphia, PA: Elsevier, 2007.
4. Buchheit, M, and Mendez-Villanueva, A. Reliability and stability of anthropometric and performance measures in highly-trained young soccer players: effect of age and maturation. J Sports Sci 31: 1332-1343, 2013.
5. Comfort, P, Stewart, A, Bloom, L, and Clarkson, B. Relationships between strength, sprint, and jump performance in well-trained youth soccer players. J Strength Cond Res 28: 173-177, 2014.
6. Datson, N, Hulton, A, Andersson, H, Lewis, T, Weston, M, Drust, B, and Gregson, W. Applied physiology of female soccer: an update. J Sports Med 44: 1225-1240, 2014.
7. De Ste Croix, M, Armstrong, N, Welsman, JR, and Sharpe, P. Longitudinal changes in isokinetic leg strength in 10-14-year-olds. Ann Hum Biol 29: 50-62, 2002.
8. DiStefano, LJ, Padua, DA, Blackburn, JT, Garrett, WE, Guskiewicz, KM, and Marshall, SW. Integrated injury prevention program improves balance and vertical jump height in children. J Strength Cond Res 24: 332-342, 2010.
9. Dos'Santos, T, Jones, PA, Comfort, P, and Thomas, C. Effect of different onset thresholds on isometric mid-thigh pull force-time variables. J Strength Cond Res 31: 3463-3473, 2017.

10. Emmonds, S, Morris, R, Murray, E, Robinson, C, Turner, L, and Jones, B. 2017. The influence of age and maturity status on the maximum and explosive strength characteristics of elite youth female soccer players. Sci Med Foot *1*: 209-215, 2017.

11. Glatthorn, JF, Gouge, S, Nussbaumer, S, Stauffacher, S, Impellizzeri, FM, and Maffiuletti, N. Validity and reliability of Optojump photoelectric cells for estimating vertical jump height. J Strength Cond Res. 25: 556-560, 2011.

12. Haff, GG, Ruben, RP, Lider, J, Twine, C, and Cormie, P. A comparison of methods for determining the rate of force development during isometric midthigh clean pulls. J Strength Cond Res 29: 386-395, 2015.

13. Hopkins, W, Marshall, S, Batterham, A, and Hanin, J. Progressive statistics for studies in sports medicine and exercise science. Med Sci Sport Exerc Sci 41: 3, 2009.

14. Jacobson, BH. A comparison of absolute, ratio and allometric scaling methods for normalizing strength in elite American football players. J Athl Enhanc, 2013.

15. Krustrup, P, Mohr, M, Amstrup, T, Rysgaard, T, Johansen, J, Steensberg, A, Pedersen, PK, and Bangsbo, J. The yo-yo intermittent recovery test: physiological response, reliability, and validity. Med Sci Sports Exerc 35: 697-705, 2003.

16. Lloyd, RS, Oliver, JL, Hughes, MG, and Williams, CA. The influence of chronological age on periods of accelerated adaptation of stretch-shortening cycle performance in pre and post-pubescent boys. J Strength Cond Res 25: 1889– 1897, 2011.

17. Lloyd, RS, Oliver, JL, Faigenbaum, AD, Myer, GD, and De Ste Croix, MB. Chronological age vs. biological maturation: Implications for exercise programming in youth. J Strength Cond Res 28: 1454–1464, 2014.

18. Lovell, R, Towlson, C, Parkin, G, Portas, M, Vaeyens, R, Cobley, S. Soccer player characteristics in English lower-league development programmes: The relationships

between relative age, maturation, anthropometry and physical fitness. PloS one 10, 2015.

19. Malina, RM, Eisenmann, JC, Cumming, SP, Ribeiro, B, and Aroso, J. Maturity-associated variation in the growth and functional capacities of youth football (soccer) players 13–15 years. Eur J Appl Physiol 91: 555-562, 2004.
20. Malina, RM. and Kozieł, SM. Validation of maturity offset in a longitudinal sample of Polish girls. J Sports Sci, 32:1374-1382, 2014.
21. Malina, RM. and Kozieł, SM. Validation of maturity offset in a longitudinal sample of Polish boys. *J Sports Sci*, *32*: 424-437, 2014.
22. Malina, RM, Choh, A., Czerwinski, SA, and Chumlea, WC. Validation of maturity offset in the Fels Longitudinal Study. Pediatr Exerc Sci 28: 439-455, 2016.
23. Meyers, RW, Oliver, JL, Hughes, MG, Cronin, JB, Lloyd, RS. Maximal sprint speed in boys of increasing maturity. Pediatr Exerc Sci 27: 85-94, 2015.
24. Meyers, RW, Oliver, J, Hughes, MG, Lloyd, RS, and Cronin, JB. Influence of age, maturity, and body size on the spatiotemporal determinants of maximal sprint speed in boys. J Strength Cond Res 31:1009-1016, 2017.
25. Meylan, CM, Cronin, JB, Oliver, JL, and Rumpf, MC. Sex-related differences in explosive actions during late childhood. J Strength Cond Res 28: 2097-2104, 2014.
26. Meylan, C, Cronin, J, Oliver, J, Hughes, M. Talent identification in soccer: The role of maturity status on physical, physiological and technical characteristics. Int J Sports Sci Coach 5: 571-592, 2010.
27. Mirwald, RL, Baxter-Jones, AD, Bailey, DA, and Beunen, GP. An assessment of maturity from anthropometric measurements. Med Sci Sports Exerc 34: 689-694, 2002.

28. Mota, J, Guerra, S, Leandro, C, Pinto, A, Ribeiro, JC, and Duarte, JA. Association of maturation, sex, and body fat in cardiorespiratory fitness. Am J Hum Biol 14: 707-712, 2002.
29. Noon, MR, James, RS, Clarke, ND, Akubat, I, and Thake, CD. Perceptions of well-being and physical performance in English elite youth footballers across a season. J Sports Sci 33: 2106-2115, 2015.
30. Oliver, J, Armstrong, N, and Williams, C. Changes in jump performance and muscle activity following soccer-specific exercise. J Sports Sci 26: 141-148, 2008.
31. Read, PJ, Oliver, JL, Croix, MBDS, Myer, GD, and Lloyd, RS. Hopping and Landing Performance in Male Youth Soccer Players: Effects of Age and Maturation. Intl J Sports Med 38: 902-908, 2017.
32. Suchomel, TJ, Nimphius, S, and Stone, MH. The importance of muscular strength in athletic performance. J Sports Med 46: 1419-1449, 2016.
33. Taylor, J, Portas, MD, Wright, MD, Hurst, C, and Weston, M. Within-season variation of fitness in elite youth female soccer players. J Athl Enhanc, Epub, 2013.
34. Vescovi, JD, Rupf, R, Brown, TD, and Marques, MC. Physical performance characteristics of high-level female soccer players 12–21 years of age. Scand J Med Sci Sports 21: 670-678, 2011.
35. Wright, MD, and Laas, MM. Strength training and metabolic conditioning for female youth and adolescent soccer players. J Strength Cond Res 38: 96-104, 2016.
36. Wright, M, and Atkinson, G. Changes in sprint-related outcomes during a period of systematic training in a girls' soccer academy. J Strength Cond Res. Epub.2017.

Table 1: Anthropometric and physical characteristics of youth female soccer players by maturity offset group

	Maturity Offset Groups (YPHV)					
	-2.5 (*n* = 24)	**-1.5 (*n* = 30)**	**-0.5 (*n* = 19)**	**0.5 (*n* = 22)**	**1.5 (*n* = 36)**	**2.5 (*n* = 27)**
Age (y)	9.16 ± 0.61	10.70 ± 0.62	11.87 ± 0.31	12.83 ± 0.67	14.01 ± 0.65	15.19 ± 0.67
Height (cm)	131.9 ± 6.3	142.4 ± 4.4	151.1 ± 4.5	157.4 ± 4.8	162.2 ± 4.4	165.8 ± 6.9
Sitting Height (cm)	67.3 ± 3.2	70.9 ± 2.9	74.8 ± 2.8	78.7 ± 2.9	82.2 ± 2.6	84.4 ± 3.9
Leg Length (cm)	64.6 ± 4.4	71.5 ± 3.6	76.4 ± 3.5	78.8 ± 2.8	80.0 ± 3.8	81.4 ± 4.1
Body Mass (kg)	28.3 ± 4.5	33.4 ± 3.8	40.5 ± 4.9	49.0 ± 5.0	54.9 ± 5.1	57.5 ± 7.5
Peak Force (N)	729 ± 105	880 ± 112	1093 ± 171	1206 ± 223	1391 ± 196	1523 ± 207
Relative Peak Force ($N \cdot Kg^{-1}$)	26.16 ± 4.22	26.44 ± 2.89	27.13 ± 4.24	24.62 ± 3.70	25.36 ± 2.73	26.68 ± 3.66
CMJ (cm)	23.46 ± 4.86	25.96 ± 4.44	28.64 ± 3.84	29.61 ± 3.52	28.63 ± 3.87	33.42 ± 4.33
10 m Sprint (s)	2.22 ± 0.13	2.21 ± 0.17	2.00 ± 0.12	2.08 ± 0.16	1.99 ± 0.14	1.98 ± 0.15
30 m Sprint (s)	5.75 ± 0.34	5.40 ± 0.64	5.09 ± 0.21	4.98 ± 0.47	4.90 ± 0.26	4.81 ± 0.27
505 CoD Dominant (s)	2.99 ± 0.39	2.73 ± 0.19	2.69 ± 0.15	2.69 ± 0.20	2.61 ± 0.15	2.54 ± 0.11
505 CoD N-Dominant (s)	3.03 ± 0.41	2.76 ± 0.19	2.71 ± 0.12	2.71 ± 0.17	2.64 ± 0.16	2.53 ± 0.08
YYIRL (m)		668 ± 284	716 ± 234	897 ± 404	888 ± 288	952 ± 320

Data are presented as mean ± standard deviations

Table 2: Standardised differences and effect sizes between consecutive maturity offset group in youth female soccer players

	Maturity Offset Groups (YPHV) comparisons				
	-2.5 *vs.* -1.5	**-1.5 *vs.* -0.5**	**-0.5 *vs.* 0.5**	**0.5 *vs.* 1.5**	**1.5 *vs.* 2.5**
Age (y)	*Most Likely* (-2.50 ± 0.62)	*Very Likely* (-2.39 ± 0.65)	*Most Likely* (-1.84 ± 0.64)	*Most Likely* (-1.79 ± 0.54)	*Most Likely* (-1.79 ± 0.50)
Height (cm)	*Most Likely* (-1.92 ± 0.56)	*Most Likely* (-1.96 ± 0.60)	*Most Likely* (-1.36 ± 0.59)	*Most Likely* (-1.04 ± 0.49)	*Very Likely* (-0.62 ± 0.44)
Sitting Height (cm)	*Most Likely* (-1.17 ± 0.50)	*Most Likely* (-1.35 ± 0.55)	*Most Likely* (-1.36 ± 0.59)	*Most Likely* (-1.29 ± 0.50)	*Very Likely* (-0.68 ± 0.44)
Leg Length (cm)	*Most Likely* (-1.71 ± 0.54)	*Very Likely* (-1.37 ± 0.55)	*Likely* (-0.77 ± 0.55)	*Possibly* (-0.37 ± 0.46)	*Possibly* (-0.34 ± 0.43)
Body Mass (kg)	*Most Likely* (-1.23 ± 0.50)	*Most Likely* (-1.61 ± 0.57)	*Most Likely* (-1.71 ± 0.62)	*Very Likely* (-1.17 ± 0.50)	*Likely* (-0.41 ± 0.43)
Peak Force (N)	*Most Likely* (-1.39 ± 0.51)	*Most Likely* (-1.47 ± 0.56)	*Likely* (-0.57 ± 0.55)	*Very Likely* (-0.88 ± 0.48)	*Very Likely* (-0.66 ± 0.44)
Relative Peak Force ($N \cdot Kg^{-1}$)	*Unclear* (-0.08 ± 0.46)	*Unclear* (-0.19 ± 0.50)	*Likely* (0.63 ± 0.55)	*Unclear* (-0.23 ± 0.46)	*Possibly* (-0.41 ± 0.43)
CMJ (cm)	*Likely* (-0.54 ± 0.47)	*Likely* (-0.65 ± 0.51)	*Unclear* (-0.26 ± 0.54)	*Possibly* (0.26 ± 0.46)	*Most Likely* (-1.17 ± 0.46)
10 m Sprint (s)	*Unclear* (0.07 ± 0.46)	*Most Likely* (1.43 ± 0.56)	*Likely* (-0.57 ± 0.54)	*Likely* (0.60 ± 0.47)	*Unclear* (0.07 ± 0.43)
30 m Sprint (s)	*Very Likely* (0.68 ± 0.47)	*Likely* (0.65 ± 0.51)	*Possibly* (0.30 ± 0.54)	*Unclear* (0.21 ± 0.46)	*Possibly* (0.34 ± 0.43)
505 CoD Dominant (s)	*Likely* (0.85 ± 0.48)	*Unclear* (0.23 ± 0.50)	*Unclear* (0.00 ± 0.53)	*Possibly* (0.45 ± 0.47)	*Likely* (0.53 ± 0.43)
505 CoD N-Dominant (s)	*Very Likely* (0.84 ± 0.48)	*Possibly* (0.31 ± 0.50)	*Unclear* (0.00 ± 0.53)	*Possibly Trivial* (0.42 ± 0.47)	*Very Likely* (0.87 ± 0.45)
YYIRL (m)		*Unclear* (-0.18 ± 0.50)	*Likely* (-0.55 ± 0.54)	*Unclear* (0.03 ± 0.46)	*Unclear* (-0.21 ± 0.43)

Magnitude based inferences and effect sizes (ES ± 90 Confidence Intervals)