Fundamental movement skills and physical fitness are key correlates of tactical soccer skill in grassroots soccer players aged 8-14 years of age

Duncan, M., Clarke, N., Bolt, L., Eyre, E. & Roscoe, C. M. P

Original citation & hyperlink: Duncan, M, Clarke, N, Bolt, L, Eyre, E & Roscoe, CMP 2022, 'Fundamental movement skills and physical fitness are key correlates of tactical soccer skill in grassroots soccer players aged 8-14 years of age', Journal of Motor Learning and Development, vol. (In-Press), pp. (In-Press). https://doi.org/10.1123/jmld.2021-0061

DOI 10.1123/jmld.2021-0061
ISSN 2325-3193
ESSN 2325-3215

Publisher: Human Kinetics

Fundamental movement skills and physical fitness are key correlates of tactical soccer skill in grassroots soccer players aged 8-14 years of age

Michael J. Duncan[1], Neil D. Clarke[1], Lee Bolt[1], Emma Eyre[1], Clare M. P. Roscoe[2]

[1]Centre for Sport, Exercise and Life Sciences, Coventry University, Coventry, UK

[2]School of Human Sciences, University of Derby, Derby, UK

Running Head: Correlates of tactical soccer skill

Address for correspondence: Michael Duncan, Centre for Sport, Exercise and Life Sciences, Coventry University, UK. Email:aa8396@coventry.ac.uk

One hundred and twenty-one children (58 boys, 63 girls) aged 8-14 years of age (Mean ± SD = 12 ± 1 years) who were regularly engaged in grassroots soccer participated in this study. Participants undertook assessments of FMS using the Test of Gross Motor Development-3, perceived ability using the Perceived Physical Ability Scale for Children, physical fitness via 15m sprint time and standing long jump distance and technical skill using the university of Ghent dribbling test. The Procedural Tactical Knowledge Test (KORA) was employed as a measure of tactical skill from which metrics for positioning and movement and recognising spaces were derived. Maturation was determined from anthropometric measures. Analysis of covariance examined gender differences in tactical skills accounting for FMS, fitness, perceived ability, technical skill, maturation and age. Results indicated no significant differences in tactical skills between boys and girls (p>.05). For recognising spaces 56% of the variance was explained with FMS (p =.001), physical fitness (p =.02) and technical skill (p =.02) contributing to the model. For positioning and movement, a significant model explained 55% of the variance in this element of tactical behaviour with FMS (p =.002) and technical skill (p =.02) significantly contributing to the model.

Keywords: Motor Competence; Motor Skill; Youth; Children; Grassroots; Talent Development; Tactics

Introduction

Recreational soccer is played by over 3.3 million children in England alone (The FA, 2015) and can provide health enhancing physical activity for children but also provides a path to more specialised sport performance through talent development programmes employed by national governing bodies in various countries (The FA, 2016; North et al., 2014). The development of soccer related motor and tactical ability is considered essential for success in soccer (Rampinini, et al., 2009), and there have been considerable efforts placed in understanding antecedents of soccer specific skill and tactical awareness in children as part of long-term athlete development (LTAD) models. By far the majority of the extant literature related to LTAD in children has focused on physical fitness as key indicators of game performance in elite and recreational youth players (Meylan et al., 2010; Unnithan et al., 2012; Höner et al., 2017; Serrano et al., 2017), with recent data demonstrating that physical fitness is a key driver of selection or deselection in junior academy football (Noon et al. 2020).

However, it has been recognised that scientists and coaches need to consider multidimensional characteristics of potential talent in soccer (Seighartsleitner, et al., 2019). Recently, there has been an emerging focus on the role that fundamental movement skills (FMS) play in the development of soccer related talent in children (Duncan, et al., 2021a; Jukic, et al., 2019; Kokstejn, et al., 2019; Rommers et al., 2018). FMS refer to the basic motor skills that form the foundation of specialized skills needed to engage successfully in sports, games, dance and other contexts of physical activity and are considered as the foundation for subsequent sports skills (Utesch and Bardid, 2019). Despite the theoretical basis suggesting that children with better FMS will perform better in sports and that developing FMS is a feature of governing body coaching awards in soccer (The FA, 2015, North, et al., 2014), there remains a lack of research examining how FMS influence soccer skills and performance in children.

Research by Jukic et al (2019) has documented those children classified as first team players had better FMS, but similar physiological fitness, than those classed as second team players in a relatively small sample (N=23) of 9–10-year-olds. Work by Kokstejn et al. (2019) has also demonstrated that the relationship between physical fitness and soccer dribbling skills was mediated by FMS in a sample of 40 elite Czech youth players. More recently, Duncan et al. (2021a) examined influences of physical fitness, perceived ability, and FMS on technical soccer skills (dribbling, passing, shooting) in 70, 7–12-year-old boys. Using path analysis Duncan et al. demonstrated that both FMS and perceived ability mediated the effect of fitness on technical skill in soccer. They subsequently suggested that focusing on physical fitness (as previously documented, Vaeyens et al., 2006), without an emphasis on FMS and enhancing a child's perceived ability in FMS, is likely to be less effective in the development of technical ability in grassroots soccer players. Such findings align with theoretical models in LTAD such as the athletic skills model (Wormhoudt et al., 2017) and the Youth Physical Development Model (Lloyd et al., 2012). Despite this, there remain several gaps in current understanding of the potential importance of FMS and perceived ability in FMS in relation to soccer performance in children. The extant literature to date has only focused on boys and, with girls' football considered the fastest growing recreational sport in the world (Valenti et al., 2018), understanding how FMS might influence (or not) football performance in females is needed. This is particularly because boys have commonly been found to demonstrate better FMS than Girls (Barnett, et al., 2008, Cohen, et al., 2015) Secondly, prior work to date has tended to focus on examining soccer specific motor skills and the extent to which fitness, FMS, and other factors relate to it (Kokstejn, et al., 2019, Jukic, et al., 2019, Duncan, et al., 2021a). Duncan et al (2021a) noted a needed next step was to establish how FMS link to tactical, as well as technical ability in youth soccer. Given the prior work of Duncan et al. (2021a) which identified the role of FMS, physical fitness and perception of ability as important contributors of technical skill performance in boys, and the work of Duarte et al. (2012) which identified that children's tactical performance was underpinned by technical skill and physical ability, the present study sought to examine the role of FMS, perceived ability and physical fitness in tactical performance in male and female youth soccer players. We hypothesised that FMS, fitness, technical skill and perceived ability would explain the variance in tactical performance in children who play grassroots soccer and that tactical performance would differ between boys and girls (Kokstejn, et al., 2019, Jukic, et al., 2019, Duncan, et al., 2021a).

Methods

Participants

One hundred and twenty-one children (58 boys, 63 girls) aged 8-14 years of age (Mean ± SD = 12 ± 1 years, 154.8 ±11.9cm, 47.1 ± 11.9kg) who were regularly engaged in grassroots soccer participated in the study following institutional ethics approval. Informed parental consent and child assent was sought prior to data collection in line with the Declaration of Helsinki (1964). The Fédération Internationale de Football Association (FIFA, 2011) define grassroots soccer as recreational soccer taking place, predominantly in children from the age of 6 years on to promote mass participation in soccer. This definition of grassroots soccer was employed in the current study to adhere to the FIFA (2011) definition as well as the structure of grassroots soccer in England. Participant response rate was 92% based on the total number of children who were approached to take part (n=132) compared to those giving consent to participate.

To be eligible to participate, children had to be registered (and playing) with a grassroots soccer club with at least one year playing experience prior to taking part and including participation in training and organised fixtures against other grassroots teams within the County FA structure in England. Mean ± SD of years playing experience for the sample was 4.2 ± 1.8 years. All participants in the current study were engaged in two-three grassroots football sessions per week, including one organised fixture against another grassroots soccer club within the same County FA. Participants were recruited from junior grassroots clubs (n=4) within Birmingham County FA and Leicestershire County FA, via contact with club secretaries who disseminated the opportunity to take part. Players then volunteered to participate, providing they were eligible.

Procedures

All assessments took place over two days. On the first day of assessment measures of perceived ability were completed first, followed by anthropometric assessment, assessment of FMS and fitness. This was followed on the second day by technical and tactical skill assessment. All assessment was conducted by trained researchers and the participants' soccer club coaches were not involved in any way. Each testing session took approximately 60 minutes.

Anthropometry and Maturity Offset

Stature (cm), sitting height (cm) and body mass (kg) were assessed to the nearest 0.1cm and 0.1 kg using a SECA anthropometer and weighing scales (SECA Instruments Ltd, Hamburg, Germany), respectively. The Moore et al (2015) prediction equation was used to determine maturity offset as a marker of biological maturation. Research has consistently suggested that studies examining performance related variables in team sports, and soccer particularly, should attempt to control for biological maturation (Koziel and Malina, 2018). Direct assessment of biological maturation in children can be difficult and poses ethical implications and, as a consequence non-invasive prediction equations have been developed, often using combinations of height, mass and sitting height to predict maturity offset. The Moore et al. (2015) equation has been validated as an appropriate measure of biological maturation in children and adolescents and has greater validity in assessing maturity offset to within ± one year in external samples compared to other similar anthropometric prediction equations such as the Mirwald et al. (2002) equation.

Fundamental Movement Skills

Fundamental movement skills (FMS) were assessed using the Test of Gross Motor Development-3 (TGMD-3, Ulrich, 2019). The following skills were selected: run, jump, hop, overhand throw, underhand throw, and catch to reflect a balance of locomotor and object control skills, without the inclusion of kick to avoid confounding the assessment of FMS and technical soccer skills. This is congruent with recent research examining the utility of FMS in soccer (Duncan, et al., 2021a). Each skill is comprised of 3-4 components, and skill mastery on the TGMD-3 requires each component to be present. While the TGMD-3 is comprised of 13 different skills, shortened versions of the TGMD are common in the literature (Bandeira, et al., 2020; Valentini, et al., 2018, Issartel et al., 2017) with different compositions of skills that are assessed, often due to cultural sensitivity, for example where in Brazil the kick has been removed as children typically score highly as children in this country have more advanced skill in that movement due to mass participation in soccer (Bandeira, et al., 2020). The six skills assessed in the present study were chosen to reflect both locomotor and object control skills and to include the FMS explicitly identified by the National Curriculum for Physical Education in England as those children should develop for lifelong physical activity and Sports Participation (Department for Education, 2013). Pilot data from our laboratory, in a sample of 32, 9-14 year olds, also demonstrated acceptable concurrent validity (r = .9) for the sum of all six skills assessed in the present study with product measures of FMS (via combined z-scores for sprint speed, standing long jump performance and throwing velocity).

Trials of each skill were video recorded (Sony Handicam CX405b, Sony, UK) and subsequently edited recordings into single film clips of individual skills with Quintic Biomechanics analysis software v21 (Quintic Consultancy Ltd., UK). Scores from two trials were summed to create a total FMS score (scored 0-50) following recommended TGMD-3 test administration guidelines (Ulrich, 2019). Two experienced FMS researchers analyzed the video clips after training in two separate 2–3-hour sessions by watching videoed skills of children's skill performances and rating these against a previously rated 'gold standard' rating. Congruent with prior research (Barnett, et al., 2014), training was considered complete when each observer's scores for the two trials differed by no more than one component per trial from the instructor score for each skill (>80% agreement) (Barnett, et al., 2014). We performed inter- and intra-rater reliability analysis for all skills between the two raters on 10% of all the videos. Intraclass correlation coefficients for inter and intra-rater reliability were .92 and .98 respectively.

Perceived Physical Ability

The Perceived Physical Ability Scale for Children (PPASC, Colella, et al., 2008) was used to assess perceived ability. The PPASC is a valid and reliable tool for children of the ages taking part in this study which assesses perceived physical ability (Colella, et al., 2008). It is a 6-item measure comprising questions reflecting strength, speed and coordinative abilities. Items are structured in response scales with a 1 to 4 format. Labels are attached to each point of the response scales to assist giving meaning to the items for the children. For example, scores for the first item range from 1 (I run very slowly) to 4 (I run very fast). The children were asked to think of themselves when playing/training in soccer and were asked to choose one of the four sentences that best represented their perceived ability. Administration followed recommended guidelines (Colella et al., 2008) with a potential score of 6-24 and higher scores represented a high self-perception of physical competence.

Physical Fitness

Two measures of physical fitness were employed; 15m sprint time and standing long jump. Each participant's 15-meter sprint time was assessed using infra-red timing gates (Fusion Sport, Coopers Plains, Australia) with sprint time converted to speed in m/s. Standing long jump was determined as distance from take-off line, to the back of the closest heel on landing and assessed using a tape measure. All testing took place on a grass surface. For sprint speed and long jump, the best of two trials (fastest speed in m/s; longest jump in centimetres) was selected for analysis. Intraclass correlation coefficients for the two measures of fitness were .9 for the 15m sprint, .94 and for the standing long jump, indicating good reliability. Testing was completed individually, and we calculated a Z-score for each of our measures of fitness and summed these Z-scores to create a composite product measure of physical fitness. Recognising that for sprint time a lower score represents better performance, whereas for standing long jump larger scores represent better performance, we inverted sprint time prior to calculating the Z-score to ensure it appropriately reflected performance.

Technical Skills

The Ghent University dribbling test (UGent) was employed as a measure of technical soccer skills in this study as previously described by Vandendriessche et al. (2012). This test was chosen given its documented reliability in children (Duncan et al., 2021b), where the reliability of other available soccer skill tests has not been demonstrated in children (Ali, 2011). This is in addition to its recognition as a valid measure of dribbling skill in children and youth (McCalman, et al., 2021). All testing took place on a grass surface with participants wearing soccer boots and was completed with the official ball size for age band (Size 3 for U8-U9, Size 4 for U10-14) as recommended by the Football Association. Testing was completed individually by the participants to minimise any peer pressure to perform. Participants completed a set circuit with four left and four right turns at different angles with a distance between cones ranging between 1 and 2.2 metres (Vandendriessche et al., 2012). Following familiarisation and a practice trial each participant undertook two attempts at the test. Each attempt was performed as quickly as possible in two steps per test: the first step was made without the ball and the second step with the ball. The time of each attempt was measured to the nearest 0.01 seconds with a handheld stopwatch. The time taken to complete the dribbling course without the ball was deducted from the time with the ball to give a skill differential reflecting dribbling skill. Lower values indicate better performance. This test has a good reliability, shown by an intra-class correlation coefficient (ICC) of $R = .870$ (CV = 3.9%) for the running component and $R = .923$ (CV = 4.5%) for the dribbling with the ball component in children (Duncan, et al., 2021b). In addition, the UGent dribbling with the ball component demonstrates good concurrent validity ($r = .92$) with performance on the Bangsbo and Mohr (2011) short dribble test based on pilot data from our lab in a sample of 32, 9-14 year olds.

Tactical skills

The Procedural Tactical Knowledge Test (KORA, Kröger and Roth 2002; Memmert, 2002) was employed as a measure of tactical skill in the current study. The KORA allows for the evaluation of tactical performance in collective sports games and reflects two key parameters inherent in tactical abilities for soccer: Positioning and movement and recognising spaces. Administration followed recognised guidelines (Memmert, 2002; Gonzalez-Villoara et al., 2015) for running the KORA. Children were videoed in a series of three vs three games on a 9m X 9m space. Each game lasted three minutes and participants are informed to pass to their teammates without a defender intercepting. When a defender intercepts a pass the game stared over from the centre of play but with the defending and attacking team swapping roles. Three games were undertaken and were video-recorded (Sony Handicam CX405b, Sony, UK) and subsequently scored by two trained raters on a scale of 0-10, with 10 representing better tactical performance. Scores were derived for off the ball movement (positioning and movement) and finding gaps (recognising spaces) as per guidelines for administration of the KORA (Memmert, 2002; Gonzalez-Villoara et al., 2015). The KORA has previously been reported as a reliable measure which demonstrates low levels of bias in junior grassroots football players (Pattinson, et al., 2021). Scores from each game were averaged to provide a measure of tactical skill for the two outcome measures: Positioning and movement and; Recognising spaces. As with FMS analysis, we performed inter- and intra-rater reliability analysis for all skills between the two raters on 10% of all the videos. Intraclass correlation coefficients for inter and intra-rater reliability were .94 and .98 respectively for positioning and movement and .92 and .96 for recognising spaces respectively.

Statistical Analysis

Analysis of covariance (ANCOVA) was employed to examine any difference in tactical skills between boys and girls, accounting for confounders. ANCOVA analysis is regarded as a form of multiple regression analysis where categorical variables (in this case sex) are of particular interest and where continuous covariates can be included within the model (See Cohen, 1968 and Hoyt, Leierer, & Millington, 2006). As a consequence, the use of ANCOVA is reported similarly to that of multiple regression where the amount of variance in the model is explained using adjusted R^2 values and beta values are used to express the association between covariates and the dependent variable (See Field, 2017). In the case of the present study, ANCOVA analysis would therefore be considered appropriate to explore the role of FMS, perceived ability and physical fitness on tactical performance in male and female youth soccer players and may be more appropriate than multiple regression due to the focus on potential sex differences, where ANCOVA is considered the appropriate technique, and where mediation analysis is not a focus of the research question (Hoyt, Imel, & Chan, 2008). Tactical skills (positioning and movement and recognising spaces) were used as the dependent variables. Sex was used as a categorical between groups factor and age, maturity offset, total FMS, perceived ability, physical fitness and technical skill were employed as covariates. This enabled any differences in tactical skills between boys and girls to be examined whilst at the same time exploring the contribution of covariates in explaining the variance in tactical skills. Pearson's product moment correlations between variables were also determined and prior to analysis data were inspected to ensure the assumptions for ANCOVA were met including lack of multicollinearity on the data, that values of residuals were independent, and the variance of the residuals was constant and were normally distributed. The Statistical Package for Social Sciences (SPSS version 25) was used for all analysis.

Results

Mean ± SD and 95% confidence intervals for all variables for the whole sample and for boys and girls separately are presented in Table 1.

Table 1 Here*

Pearson's product moment relationships split by sex are presented in Table 2 for boys and Table 3 for girls. For boys, relationships were significant between all variables (*p* <.01, See Table 2). However, for girls, the pattern of relationships was different to that of boys where there were significant relationships between variables, with the exception of age, where there were no significant relationships between age and any of the other variables (See Table 3, *p* >.05). In addition, maturation was only significantly related with physical fitness and total FMS (both *p* <.05). To illustrate results for tactical performance stratified by age, scatterplots for recognising spaces are presented for boys and girls in Figure 1a and b respectively and for positioning and movement in Figure 2a and 2b respectively.

Table 2 and 3 Here

Figure 1 and 2 Here

Results from ANCOVA indicated a model which explained 56% of the variance (Adj R^2 = .567) for the recognising spaces element of the KORA. There was no significant sex difference in recognising space (*p* >.05) and the covariates of age, maturity offset and perceived ability were not significant (p >.05). However, total FMS ($F_{1,113}$ = 11.1, β=.114, *p* =.001, $P\eta^2$=.08), physical fitness ($F_{1,113}$ = 7.3, β=.258, *p* =.02, $P\eta^2$=.04), and technical skill ($F_{1,113}$ = 6.1, β=-.09, *p* =.02, $P\eta^2$=.05) significantly contributed to the model. Of note, beta values indicated that total FMS and physical fitness were more important contributors in the model than technical skill, with a one unit change in FMS and physical fitness being associated with a .114 and .258 unit change in scores for recognising space.

Results for the positioning and movement aspect of the KORA similarly demonstrated a significant model which explained 55% of the variance (Adj R^2 = .55) in this element of tactical behaviour. There was no significant sex difference in recognising space (p >.05) and the covariates of age, maturity offset, perceived ability and technical skill were not significant (p >.05). However, total FMS ($F_{1,113}$ = 10.5, β=.117, p =.002, $P\eta^2$=.08), and physical fitness ($F_{1,113}$ = 5.7, β=.29, p =.02, $P\eta^2$=.05) significantly contributed to the model.

Discussion

The present study examined the role of FMS, perceived ability, and physical fitness in tactical performance in male and female youth soccer players. The findings of the current study suggest that, in youth recreational grassroots soccer players, competence in FMS, technical skill and physical fitness are key in explaining tactical skills. FMS, technical skill and physical fitness are particularly important in the tactical skill of recognising spaces (i.e., findings gaps to play through/in) while only FMS and physical fitness were significant in explaining tactical skills for movement off the ball (i.e., positioning and movement). This is the first study to date to examine the potential importance of FMS and perceived ability alongside other relevant factors such as technical skill, fitness, and maturation in explaining tactical soccer skill in youth players. As a consequence, the results of the present study extends understanding of contributors to soccer performance in children and adolescents. Importantly, the current study examined both male and female players, where prior work has almost entirely focused on males. Of note, there were no significant differences in tactical skills demonstrated between boys and girls in the current study. Prior research does not appear to have examined any differences in tactical performance between boys and girls, although there is evidence in elite adult players that there are gender differences in champions league match play (Bradley, et al., 2014) and in technical-tactical behaviour in La Liga matches (Casal, et al., 2021).

The results of the current study reinforce that the historical over reliance on physical attributes and body size in coach decisions relating to soccer talent in children (Vaeyens et al., 2006) or that solely emphasising physical fitness development (e.g., Deprez, et al., 2015) for success in soccer is misguided. The results of the present study align with assertions made by Duncan et al. (2021a) that FMS is key in youth soccer skill development. However, the work of the current study extends that of Duncan et al. (2021a) by examining tactical skill via small-sided game performance. This should be considered a novel aspect of the present study. The results of the present study also reinforce the assertions made by key theoretical models such as the Athletic Skills Model (Wormhoudt et al., 2017), which position the development of FMS as the foundation for more specialised sport performance.

It is important to note that both aspects of tactical performance examined in the current study (recognising spaces and positioning and movement) were significantly related to technical skill, physical fitness, FMS, perceived ability, age and maturation offset in boys but only with technical skill, physical fitness, FMS, and perceived ability in girls. The reason for the difference in pattern of relationships between boys and girls is not known. However, it is possible that playing experience would also have influenced the impact of the dependent variables, particularly technical skill, on tactical performance. This is on the basis that greater experience in grassroots football might translate to greater time practising in skill development. Recent work by De Waelle et al. (2021) has highlighted that visual cognition, a variable related to tactical performance, was related to age in youth volleyball players, but that this relationship was mediated by playing experience. In the present study, although data relating to playing experience was collected, the variation in experience was not sufficient in our sample to examine the potentially mediating role of experience, over age, on tactical performance. Likewise, there remains considerable unexplained variance in the models arising from the results of the present study. In addition, to the variables included in the current study, other technical skills, such as passing and dribbling, cognition, and potentially other aspects of physical fitness might be useful in further illuminating the multidimensional contributors to tactical performance in youth soccer.

Recent work has also suggested that perception of competence is key in understanding the effect of physical fitness on soccer skill (Duncan et al., 2021a) as well as perceived ability being a key driver of children's FMS (Barnett, et al., 2011) and being suggested as important in the development of children's soccer skills (Kokstejn, et al., 2019). The results of the present study are contrary to the prior work of Duncan et al. (2021), which examined technical soccer skills and suggested coaches should promote positive perception of ability for the benefit of actual soccer skills. We agree that children's soccer coaches should seek to promote a positive perception of competence in those they coach. However, the results of the present study suggest that perceived ability is not associated with tactical soccer skill in the same manner that has been reported for technical soccer skills.

A key question which also needs to be considered is what the potential mechanism for physical fitness, FMS and technical skill is, in explaining the variance in tactical performance in soccer. Within team sport, particularly soccer, it is recognised that performance does not manifest itself as separate components, but rather as a whole where different components, including those assessed in the present study, interact with each other to produce overall soccer performance (Duarte, et al., 2012). The assessment of tactical skill in the present study, via the KORA, comprised an assessment of two key aspects of tactical behaviour, recognising spaces and positioning and movement, determined through small sided game activity. In this context children's tactical performance (i.e., understanding 'what to do') is underpinned by their ability to solve in-game problems (i.e. knowing and being able to execute 'how to do it') (Duarte, et al., 2012). In such circumstances the performer should select the most optimal motor response in an intelligent or creative manner for the given situation on the pitch for success (Duarte, et al., 2012). As a consequence, tactical performance where movement is required, such as that used in the present study, is underpinned by technical skills where the tactical decisions taken (i.e., the what to do) are influenced by the performers ability technically to execute skills, such as passing, dribbling, etc in the given situation. Similarly, greater levels of FMS underpin execution of more specific sports skills and greater physical fitness enables execution of sport specific skills more effectively with skill preservation due to increased resistance to fatigue. Tactical performance is therefore associated with technical skill, FMS and physical fitness in an integrative manner where the optimal automation of technical skills, via competence in FMS and higher physical fitness, entails better possibilities for a player to recognise and execute tactical strategies as this automation frees up attentional resource that can be devoted to tactical and other objectives in soccer situations (Kannekens, et al., 2011). This suggestion is not new and has featured in recent systematic review data examining talent development in youth athletes (Koopman, et al., 2020) and empirical work examining talent development in soccer specifically (Kannekens, et al., 2011) and sport more broadly (Lidor, et al., 2009).

The participants in the present study were grassroots soccer players, engaged in regular training and fixtures against other teams. We recruited participants using FIFA's (2011) definition of grassroots soccer for the present study and the results of the present study should be considered in the context of that group, rather than children already recruited into professional soccer academies. The participants in the current study were all drawn from English grassroots soccer clubs and are thus reflective of the development system at grassroots level employed by the English FA. It is possible there are cross cultural differences in practices of coaches at grassroots levels in their philosophy related to developing FMS and perceived ability through their football coaching. The importance of fitness, FMS, perceived ability and technical skill on tactical performance may therefore differ depending which country the participants are drawn from. We are also cognisant that we employed a measure of dribbling skill as an indicator of overall technical ability and tactical skills may relate different to other aspects of technical ability, such as shooting and passing. In the current study we followed guidelines for selection of tactical skill assessments suggested by Gonzalez-Villoara et al. (2015). The KORA was employed as a measure of tactical soccer performance in the current study and has been recommended by prior authors for the assessment of tactical skill in children of the ages recruited in the present study (Gonzalez-Villoara et al., 2015). However, the KORA is considered an 'intermediate' tactical assessment (Gonzalez-Villoara et al., 2015), which provides information of high enough fidelity to grade tactical skill (Kröger and Roth 2002; Memmert, 2002). The quantification of recognising spaces and positioning and movement, via the KORA, are purported to relate to a player's ability to get to the optimum position at the right time and to identify opportunities to score a goal respectively (Kröger and Roth 2002). However, there are more in-depth analysis of tactical skill that can be undertaken via in-game video assessment (Clemente, et al., 2013) or more labour-intensive methods such as the Game Performance Evaluation Tool (Garcia-Lopez, et al., 2013). It may therefore be useful for future research to examine how the variables assessed in the present study relate to actual match based tactical performance. Such an undertaking would however be time and labour intensive and is one of the main reasons cited in the literature why tactical assessments are often overlooked (Gonzalez-Villoara et al., 2015). There are some additional limitations that also should be acknowledged, the sample is relatively small given the age range employed in the present study. Physical fitness was also assessed using two fitness tests, combined into one z-score. While we conceptualise this to reflect physical fitness and our ability to assess multiple aspects of fitness was not possible due to time and other constraints, it is important to note that assessing a larger number of fitness tests (such as cardiovascular endurance or flexibility) would have enabled a broader conception of physical fitness than is the case in the current study. In addition, maturity was estimated based on anthropometric measurements, due to the ethical considerations associated with direct assessment of maturation in children. However, anthropometric estimation of maturity status is not without error, particularly for individuals further away from age at peak height velocity. Future research should therefore seek to use direct determination of maturation status where this is feasible.

Conclusion

The current study suggests that, in youth recreational grassroots soccer players, competence in FMS, technical skill and physical fitness, and not perceived ability or maturation, are key in explaining tactical skills. For coaches and those working with young players, focusing on development of FMS alongside technical skills and fitness may therefore be beneficial for holistic soccer development.

References

Ali, A. (2011). Measuring soccer skill performance: A review. Scandinavian *Journal of Medicine and Science in Sports*, 21, 170–183.

Bandeira, P., Duncan, M., Pessoa, M. L., Soares, I., Da Silva, L., Mota, J., & Martins, C. (2020). TGMD-2 short version: Evidence of validity and associations with sex, age and BMI in preschool children. *Journal of Motor Learning and Development*, 8(3), 528–543.

Bangsbo, J., and Mohr, M. (2011). Fitness Testing in Football. Denmark: Stormtryk.

Barnett, L. M., Minto, C., Lander, N., Hardy, L. L. (2014). Interrater reliability assessment using the Test of Gross Motor Development-2. *Journal of Science and Medicine in Sport*, 17, 667-670.

Barnett, L. M., Morgan, P. J., Van Beurden, E., Ball, K., Lubans, D. R. (2011). A reverse pathway? Actual and perceived skill proficiency and physical activity. *Medicine and Science in Sports and Exercise*, 43, 898–904.

Barnett, L.M., Van Beurden, E., Morgan, P.J., Brooks, L.O., & Beard, J.R. (2008). Does childhood motor skill proficiency predict adolescent fitness? *Medicine and Science in Sports and Exercise*, 40(12), 2137–2144.

Bradley, P. S., Dellal, A., Mohr, M., Castellano, J., & Wilkie, A. (2014). Gender differences in match performance characteristics of soccer players competing in the UEFA Champions League. *Human Movement Science*, *33*, 159–171.

Casal, C.A., Losada, J.L., Maneiro, R., & Ardá, A. (2021). Gender differences in technical-tactical behaviour of La Liga Spanish football teams. *Journal of Human Sport and Exercise,* 16(1), 37-52.

Clemente, F. M., Couceiro, M. S., Martins, F. M. L., Mendes, R., Figueiredo, A. J. (2013). Measuring collective behaviour in Football teams: inspecting the impact of each half of the match on ball possession. *International Journal of Performance Analysis in Sport*, 13, 678–689.

Cohen, J. (1968). Multiple regression as a general data-analytic strategy. *Psychological Bulletin*, 70, 426–443.

Cohen, K.E., Morgan, P.J., Plotnikoff, R.C., Callister, R., & Lubans, D.R. (2015). Physical activity and skills intervention: Scores cluster randomized controlled trial. *Medicine and Science in Sports and Exercise*, 47(4), 765–774.

Colella, D., Morano, M., Bortoli, A., Robazza, C. (2008). A physical self efficacy scale for children. *Social Behaviour and Personality*, 36, 841-848.

Department for Education (2013). *Physical education programmes of study: key stages 1 and 2, The National Curriculum*. London: Department for Education.

Deprez, D., Valente-Dos-Santos, J., Coelho-e-Silva, M. J., Lenoir, M., Philippaerts, R., and Vaeyens, R. (2015). Longitudinal development of explosive leg power from childhood to adulthood in soccer players. *International Journal of Sports Medicine,* 36, 672–679.

De Waelle, S., Van Bostraeten, S., Lenoir, M., Deconinck, F., Bennet, S. (2021). Visual cognition and experience mediate the relation between age and decision making in youth volleyball players. *Optometry and Vision Science,* 98, 802-808.

Duarte, R., Araújo, D., Freire, L., Folgado, H., Fernandes, O., & Davids, K. (2012). Intra- and inter-group coordination patterns reveal collective behaviors of football players near the scoring zone. *Human Movement Science*, *31*(6), 1639–1651.

Duncan, M. J., Eyre, E., Noon, M. R., Morris, R., Doug Thake, C., Clarke, N. D., & Cunningham, A. J. (2021a). Actual and perceived motor competence mediate the relationship between physical fitness and technical skill performance in young soccer players. *European Journal of Sport Science*, e-pub ahead of print.

Duncan, M., Richardson, D., Morris, R., Eyre, E., & Clarke, N. (2021b). Test-retest reliability of soccer dribbling tests in children. *Journal of Motor Learning and Development*, *(In-press)*.

Field, A. (2017) Discovering Statistics Using IBM SPSS statistics. London: Sage.

FIFA (2011). Grassroots Football. Zurich: FIFA. Available from: https://www.fifa.com/who-we-are/news/grassroots-goes-live-fifa-com-1462069

García-López, L. M., González-Víllora, S., Gutiérrez-Díaz, D., Serra-Olivares, J. (2013). Development and validation of the game performance evaluation tool (GPET) in soccer. *Revista Euroamericana de Ciencias del Deporte,* 2(1):89–99.

González-Víllora, S., Serra-Olivares, J., Pastor-Vicedo, J. C., & da Costa, I. T. (2015). Review of the tactical evaluation tools for youth players, assessing the tactics in team sports: football. *SpringerPlus*, *4*, 663.

Höner, O., Leyhr, D., Kelava, A. (2017). The influence of speed abilities and technical skills in early adolescence on adult success in soccer: a long term prospective analysis using ANOVA and SEM approaches. *PLoS One,* 12, e0182211.

Hoyt, W. T., Imel, Z., Chan, F. (2008). Multiple regression and correlation techniques: Recent controversies and best practices. *Rehabilitation Psychology*, 53, 321-339.

Hoyt, W. T. Leierer, S., Millington, M. J. (2006). Analysis and interpretation of multiple regression techniques. *Rehabilitation Counselling Bulletin*, 49, 223-233.

Issartel, J., McGrane, B., Fletcher, R., O'Brien, W., Powell, D., & Belton, S. (2017). A cross-validation study of the TGMD-2: The case of an adolescent population. *Journal of Science Medicine and Sport*, 20(5), 475–479.

Jukic, I., Prnjak, K., Zoellner, A., Tufano, J. J., Sekulic, D., Salaj, S. (2019). The Importance of Fundamental Motor Skills in Identifying Differences in Performance Levels of U10 Soccer Players. *Sports*. 7, 178.

Kannekens, R., Elferink-Gemser, M. T., & Visscher, C. (2011). Positioning and deciding: key factors for talent development in soccer. *Scandinavian Journal of Medicine & Science in Sports*, *21*(6), 846–852.

Kokstejn, J., Musalek, M., Wolanski, P., Murawska-Cialowicz, E., Stastny, P. (2019). Fundamental Motor Skills Mediate the Relationship Between Physical Fitness and Soccer-Specific Motor Skills in Young Soccer Players. *Frontiers in Physiology,* 10,596.

Koopmann, T., Faber, I., Baker, J., & Schorer, J. (2020). Assessing Technical Skills in Talented Youth Athletes: A Systematic Review. *Sports Medicine*, *50*(9), 1593–1611.

Kozieł, S. M., & Malina, R. M. (2018). Modified Maturity Offset Prediction Equations: Validation in Independent Longitudinal Samples of Boys and Girls. *Sports Medicine*, *48*(1), 221–236.

Kröger, C., Roth, K. (2002). Escola da bola: Um ABC para iniciantes nos jogos espor- tivos [School ball: An ABC Sports games for beginners]. Phorte, Sâo Paulo.

Lidor, R., Cote, J., Hackfort. D. (2009). ISSP position stand: To test or not to test? The use of physical skill tests in talent detection and in early phases of sport development. *International Journal of Sport and Exercise Psychology*, 7(2), 131–46.

Lloyd, R. S., Oliver, J. L. (2012). The youth physical development model: a new approach to long-term athletic development. Strength and Conditioning Journal, 34, 61–72.

McCalman, W., Crowley-McHattan, Z. J., Fransen, J., & Bennett, K. (2021). Skill assessments in youth soccer: A scoping review. *Journal of Sports Sciences*, e-pub ahead of print.

Memmert, D. (2002). Diagnostik taktischer leistungskomponenten: Spieltestsitu- ationen und konzeptorientierte expertenratings [Tactical performance components valuation: test situations and concept-oriented expert ratings]. Ph.D. Dissertation. Heidelberg University, Heidelberg.

Mirwald, R. L., Baxter-Jones, A. D., 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.

Meylan, C., Cronin, J., Oliver, J., and Hughes, M. (2010). Talent identification in soccer: the role of maturity status on physical, physiological and technical characteristics. *International Journal of Sports Science and Coaching,* 5, 571–592.

Moore, S. A., McKay, H. A., Macdonald, H., Nettlefold, L., Baxter-Jones, A. D., Cameron, N., & Brasher, P. M. (2015). Enhancing a Somatic Maturity Prediction Model. *Medicine and science in sports and exercise*, *47*(8), 1755–1764.

North, J., Lara-Bercial, S., Morgan, G., Rongen, F., Broche, D., Nentwig, G., Sadys Frederic, Sargison, J. (2014). The identification of good practice principles to inform player development and coaching in European youth football. Zurich: UEFA.

Noon, M. R., Eyre, E. L.J., Ellis, M., Myers, T. D., Morris, R. O., Mundy, P. D., Penny, R., Clarke, N. D. (2020). The Influence of Recruitment Age and Anthropometric and Physical Characteristics on the Development Pathway of English Academy Football Players. *International Journal of Sports Physiology and Performance*, 16, 199-207.

Pattinson, W., Eyre, E., Noon, M., Duncan, M. J. (2021) Test retest reliability of technical and tactical skill tests in grassroots footballers. Presentation at the Annual Expertise and Skill Acquisition conference 2021. Available from: https://www.esan-network.co.uk/poster-11.html

Rampinini, E., Impellizzeri, F. M., Castagna, C., Coutts, A. J., and Wisløff, U. (2009). Technical performance during soccer matches of the Italian serie a league: effect of fatigue and competitive level. *Journal of Science and Medicine in Sport,* 12, 227–233.

Rommers, N., Mostaert, M., Goossens, L., Vaeyens, R., Witvrouw, E., Lenoir, M., et al. (2018). Age and maturity related differences in motor coordination among male elite youth soccer players. *Journal of Sports Sciences*, 37, 196–203.

Sieghartsleitner, R., Zuber, C., Zibung, M., Conzelmann, A. (2019). Science or Coaches' Eye? - Both! Beneficial Collaboration of Multidimensional Measurements and Coach Assessments for Efficient Talent Selection in Elite Youth Football. *Journal of Sports Science and Medicine*, 18(1), 32-43.

Serrano, J. S., Pizarro, A. P., García-González, L., Domínguez, A. M., and Álvarez, F. V. (2017). Evolution of tactical behavior of soccer players across their development. *International Journal of Performance Analysis in Sport*, 17, 885–901.

The FA (2015). State of the game. Staffordshire: The FA. Available from: https://www.thefa.com/news/2015/jun/10/11-million-playing-football-in-england

The FA (2016). Fundamental Movements in the Foundation Stage. Staffordshire: The FA. Available from: http://www.thefa.com/learning/coaching/fundamental-movements-in-the-foundation-phase

Ulrich, D. A. (2019). *Test of Gross Motor Development*. (3rd ed.) Austin, TX: PRO-ED.

Unnithan, V., White, J., Georgiou, A., Iga, J., and Drust, B. (2012). Talent identification in youth soccer. *Journal of Sports Sciences.* 30, 1719–1726.

Vaeyens, R., Lenoir, M., Williams, A.M., Philippaerts, R.M., (2008). Talent identification and development programmes in sport: current models and future directions. *Sports Medicine*, 38 (9), 703–714.

Valenti, M., Scelles, N., Morrow, S. (2018). Women's football studies: an integrative review. *Sport, Business and Management: An international journal*, 8 (5), 511–528.

Valentini, N. C., Rudisill, M. E., Bandeira, P., & Hastie, P. A. (2018). The development of a short form of the Test of Gross Motor Development-2 in Brazilian children: Validity and reliability. *Child: Care, Health and Development*, *44*(5), 759–765.

Vandendriessche, J. B., Vaeyens, R., Vandorpe, B., Lenoir, M., Lefevre, J., and Philippaerts, R. M. (2012). Biological maturation, morphology, fitness, and motor coordination as part of a selection strategy in the search for international youth soccer players (age 15–16 years). *Journal of Sports Sciences,* 30, 1695–1703.

Wormhoudt, R., Savelsbergh, G., Teunissen, J., Davids, K. (2017). The Athletic Skills Model. London: Routledge.

	Whole Sample (n=121)			Boys (n=58)			Girls (n=63)		
	Mean	SD	95% CI	Mean	SD	95% CI	Mean	SD	95% CI
Age (Years)	12.0	1.6	11.7-12.3	12.4	1.7	11.9-12.9	11.59	1.4	11.2-12.00
Maturation Offset (years from PHV)	-.83	1.5	-1.1- -.54	-1.6	1.4	-2.0 - -1.2	-0.78	1.3	-4.4-0.3
Technical Skill (secs)	29.2	4.0	28.4-29.9	27.9[a]	4.3	26.8-29.2	30.3[a]	3.4	29.4-31.1
Physical Fitness (z-score)	-.01	1.9	-.35-.33	0.5[b]	2.3	-.08-1.14	-.51[b]	1.5	-.82- -.20
Total FMS (0-48)	35.7	6.1	34.5-36.7	38.8[c]	5.6	37.4-40.3	32.7[c]	4.9	31.5-33.9
Perceived ability (6-24)	17.7	2.8	17.2-18.3	18.6[d]	3.2	17.8-19.5	16.9[d]	2.2	16.4-17.5
Positioning and Movement (0-10)	4.6	1.8	4.2-4.9	5.0	1.8	4.5-5.5	4.1	3.1	3.7-4.6
Recognising Space (0-10)	4.4	1.8	4.1-4.7	4.8	1.9	4.3-5.3	4.0	1.7	3.6-4.4

Table 1. Mean ± SD and 95% confidence intervals of age, maturation offset, technical skill, physical fitness z-score, total FMS, perceived physical competence and scores for positioning and movement and recognising space ([a]p=.01, boys = better performance, [b]p=.02, boys = better performance, [c]p=.001, boys = better performance, [d]p=.0001 boys = better performance).

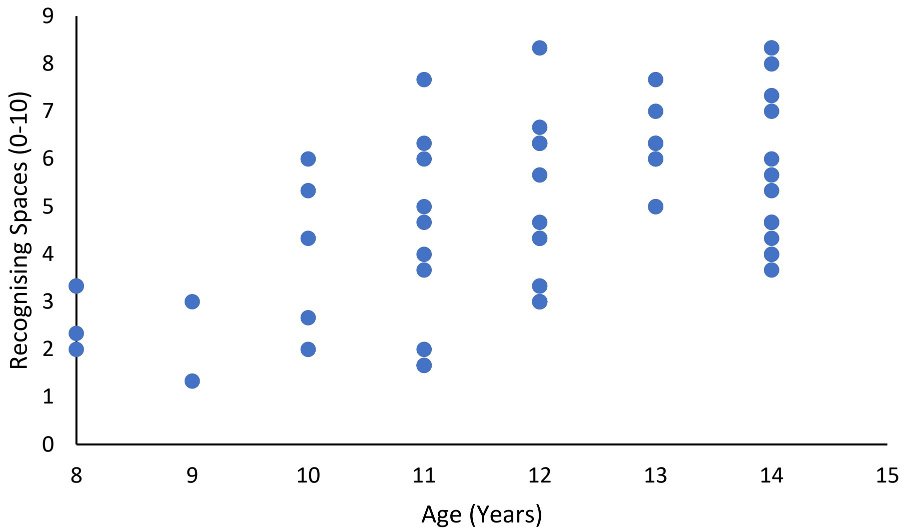
	Maturation Offset	Technical Skill	Physical Fitness	Total FMS	Perceived ability	Positioning and Movement	Recognising Space
Age	r=.79**	r=-.46**	r=.78**	r=.65**	r=.45**	r=.49**	r=.51**
Maturation Offset		r=-.41**	r=.59**	r=.55**	r=.34**	r=.37**	r=.36**
Technical Skill			r=-.68**	r=-.59**	r=-.61**	r=-.71**	r=-.72**
Physical Fitness				r=.80**	r=.63**	r=.72**	r=.73**
Total FMS					r=.629**	r=.75**	r=.74**
Perceived ability						r=.66**	r=.63**
Positioning and Movement							r=.95**

Table 2. Pearson's product moment correlations between variables for boys (**P<.01, *P<.05).

	Maturation Offset	Technical Skill	Physical Fitness	Total FMS	Perceived ability	Positioning and Movement	Recognising Space
Age	r=.97**	r=-.07	r=.21	r=.21	r=-.06	r=.18	r=.16
Maturation Offset		r=-.12	r=.25*	r=.24*	r=-.06	r=.21	r=.19
Technical Skill			r=-.38**	r=-.45**	r=-.35**	r=-.29**	r=-.38**
Physical Fitness				r=.80**	r=.43**	r=.67**	r=.68**
Total FMS					r=.34**	r=.60**	r=.62**
Perceived ability						r=.37**	r=.38**
Positioning and Movement							r=.94**

Table 3. Pearson's product moment correlations between variables for girls (**P<.01, *P<.05).

1a



1b

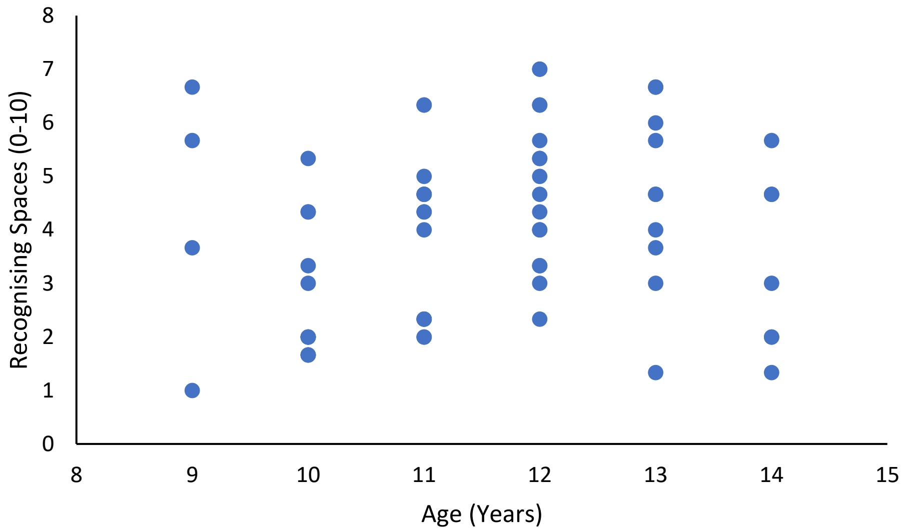
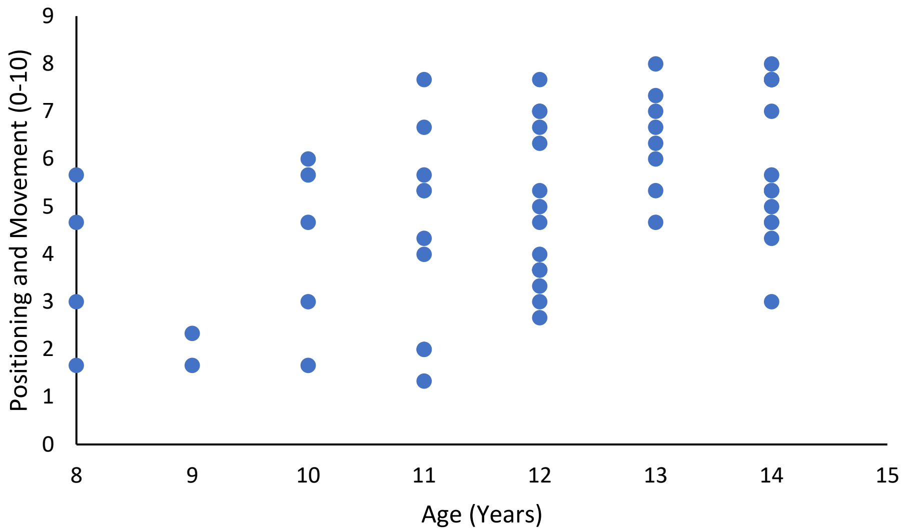


Figure 1. Scatterplot illustrating the results for tactical performance (recognising spaces) for a) boys and b) girls

2a



2b

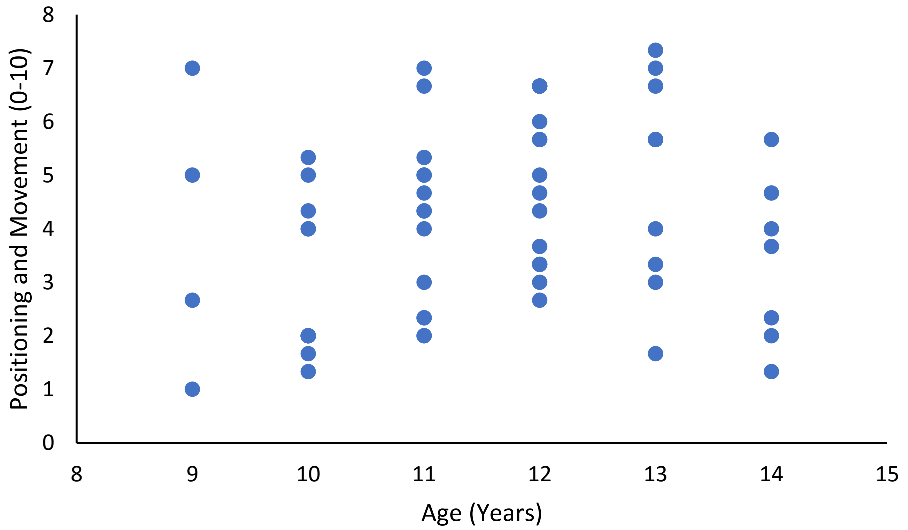


Figure 2. Scatterplot illustrating the results for tactical performance (positioning and movement) for a) boys and b) girls