ANTHROPOMETRIC AND PHYSIOLOGICAL PREDICTORS OF SOCCER SKILLS IN YOUTH SOCCER PLAYERS

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Authors’ Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract
Study purpose. This study aimed at investigating the anthropometric and physiological characteristics that affect soccer skills in advanced-level youth soccer players.

Materials and methods. Ninety advanced youth male soccer players from the U-18 division 1 soccer club were enrolled to participate in this study. The participants were classified into three different positions: defenders, midfielders, and forwards. The anthropometric profiles (height, weight, and body fat) and physiological variables (Y-balance test, Yo-Yo Intermittent Recovery Test Level 1, running-based anaerobic sprint test, sit-up test, countermovement jump test, drop jump test, arrowhead agility test, and 40-m sprint test) were assessed. Soccer-specific skills were measured using the Loughborough soccer passing and shooting protocol.

Results. The multiple regression analysis revealed a statistically significant relationship between physical factors and the Loughborough soccer passing ability ($R^2 = 0.291$, $F_{(15, 74)} = 2.200$, $p = 0.015$). The results indicated that the relative maximum power displayed the strongest association with passing ability, followed by sit-up, countermovement jump without and with arm swing, and fatigue index. Concerning the shooting performance, the predictors accounted for 21.8% of the variance, with sit-up being the sole significant predictor among other factors.

Conclusions. Our findings underscore the significance of relative maximum power, fatigue tolerance, muscular power, and core strength as valuable predictors for enhancing passing ability. In addition, abdominal strength emerged as a crucial indicator of shooting performance. Soccer coaches could use the essential information described in this study for talent identification purposes.

Keywords: physical fitness, muscular power, soccer passing, talent identification, youth soccer.

Introduction

Soccer is a highly unpredictable opened-skill sport that requires exceptional physiological abilities on the professional level, as well as proficiency in movement, motor control, decision-making, and cognitive function (Reilly et al., 2000; Fernandez-Rio & Méndez-Giménez, 2014; Romeas et al., 2016). Renowned, world-class-level soccer players such as Lionel Messi, Christiano Ronaldo, Neymar da Silva Santos Júnior, and Kylian Mbappé have demonstrated exceptional talent from a young age. Therefore, national soccer associations and youth academies of professional clubs worldwide have made significant financial investments in systematically implementing talent identification and development (TID) programs. The primary objective of these initiatives is to identify the most promising young athletes who possess the potential to advance to and excel at the adult professional level (Bergkamp et al., 2019; Mourao, 2016; Till & Baker, 2020). Obviously, numerous soccer clubs and academies prioritize early enrollment as a crucial aspect of long-term player development in the pursuit of training elite players. Performance success in team sports such as soccer
could be reportedly influenced by several critical factors, including anthropometry, physiological fitness, cognitive/psychological characteristics, sport-specific skills, and sociological profiles (Murr, Raabe, & Höner, 2018; Yongtavee et al., 2022). Certainly these parameters have been identified as talent predictors in systematic review studies (Williams & Reilly, 2020). For instance, top professional-level players reportedly exhibit significant differences in traits such as leanness, height, weight, physical fitness, speed, agility, and skill level during adolescence compared to their peers (Carling et al., 2012; Williams, Ford, & Drust, 2020). In the context of TID programs across various countries, specific indicators have been identified that predict future success in adulthood during the early adolescence phase in Germany. These indicators include sprinting ability, agility, dribbling skills, ball control, and shooting proficiency (Höner, Leyhr, & Kelava, 2017). In England, the Elite Player Performance Plan has been implemented since 2012 to optimize homegrown player performance across multiple domains, including physical, technical, tactical, and psychological aspects, through a comprehensive multidisciplinary approach (Premier League, 2012). Likewise, in the Netherlands, several professional soccer clubs have implemented the TID process that primarily involves evaluating a comprehensive test battery assessing multidimensional performance characteristics encompassing physiological, technical, tactical, and psychological aspects (Huigen, Elferink-Gemser, Lemmink, & Visscher, 2014). Therefore, holistic performance diagnostics appear to be crucial for the long-term international success of national football associations and professional clubs.

In order to reach the pinnacle of professional soccer, young soccer players need to enhance their performance in multiple domains, including physiological, technical, tactical, and cognitive/psychological characteristics (Meylan, et al., 2010; Reilly et al., 2000; Vaeyens et al., 2006). Moreover, when selecting elite athletes, factors such as body composition, aerobic endurance, speed, agility, and balance are crucial. Wong et al. (2009) suggest that anthropometric data can serve as reliable indicators of soccer performance. In the contemporary soccer system, teams often adopt a compact playing style, making it challenging for opponents to create space. Possessing excellent passing skills is thus vital for the players of a soccer team to maintain possession and control the game (Gonçalves et al., 2017; Rein et al., 2017). Developing shooting skills is crucial for soccer players as it is essential for winning games and overall success (Lago-Ballesteros & Lago- Peñas, 2010). Therefore, coaches should consider significantly these specific skills. However, our knowledge concerning the influence of anthropometric and physical fitness profiles on specific skills, such as passing and shooting ability, remains limited. Hence, understanding these physical demands would be essential for recruiting top-level players, particularly considering the positional differences among youth soccer players. Consequently, this study aimed at investigating how anthropometric and physiological characteristics affect soccer skills in advanced-level youth soccer players.

Materials and methods

Participants

We recruited 90 advanced youth male soccer players from the U-18 division 1 soccer club to participate in this study. Each cohort comprised a diverse group of players from different positions including defender, midfielder, and forward. All participants had at least 2 years of experience in the national youth competition. None of the participants had musculoskeletal injuries or used anabolic drugs. We informed all the participants about the purpose of the testing procedures and possible risks and gave their informed consent prior to the study. The study protocol was approved by the Ethics Review Committee for Research Involving Human Research Subjects and it was conducted according to the Declaration of Helsinki.

Testing procedures

To evaluate anthropometric and physiological characteristics, we applied nine physical fitness tests as follows: 40-m sprint, Arrowhead Agility Test (AAT), sit-up, muscular power test (i.e., Countermovement Jump (CMJ) and Drop Jump (DJ) tests), Y-Balance test, Running-based Anaerobic Sprint Test (RAST), and Yo-Yo Intermittent Recovery Test level 1 (Yo-Yo IR1). Prior to testing, the participants were instructed to engage in a 15-min individual warm-up involving low aerobic activity and dynamic stretching. Each testing session was divided into two occasions separated by a 24-h recovery period. On the first visit, the demographic data, anthropometrical aspects, and two soccer skill tests (passing and shooting) were measured on the soccer pitch. On the second visit, the physiological profiles were assessed in the following sequence: YBT, sit-up, AAT, CMJ, DJ, 40-m sprint, RAST, and Yo-Yo IR1.

Anthropometry

Standing height was measured to the nearest 0.1 cm (Seca 220e, Hamburg, Germany). Body composition analysis was performed using Inbody 720 (Biospace Co., Seoul, Korea). Fat percentage was recorded using multifrequency bioelectrical impedance analysis.

Aerobic capacity

Aerobic performance was evaluated using Yo-Yo IR1. The participants performed repeated 20-m shuttle runs interspersed with a short active recovery. The time allowed for a shuttle, which progressively decreased, dictated by audio beeps. The objective of the tests was to complete as many shuttles as possible. To calculate maximal oxygen consumption, we used the following equation, as described previously (Bangsbo, 1994):

$$VO_{2\text{max}} (\text{ml/min/kg}) = \frac{\text{running distance covered (m)}}{0.0084 + 36.4}$$

Anaerobic capacity

The RAST included $6 \times 35$ m sprints, interspersed by 10 s of active recovery (Draper and Whyte, 1997). The participants were requested to perform the sprints to the best of their abilities in each lap. Two photocells were used to record sprint time intervals. We assessed relative maximum power ($Power = \text{Weight} \times \frac{\text{Distance}^2}{\text{Time}^3}$) and fatigue index ($\frac{\text{Maximum power} - \text{Minimum power}}{\text{Total time for the six sprints}}$)/body mass based on the RAST results.
Muscular power

Muscular power values were measured using SmartSpeed Pro timing lights and force plate (Fusion Sport, Coopers Plains, Australia) during CMJ with and without arm swing and DJ. The participants completed the power test consisting of three jumps of one maximal CMJ on a force plate. The maximum value was selected as the final measurement. A 15-sec resting period was established to enable sufficient recovery between the jumps. Jump heights were recorded for each trial. DJ was performed from a 30-cm box while the participants were holding their hands on their hips. The participants were instructed to stand on the top of the box facing toward the force platform then step off of the box and rebound as fast as possible.

Muscular endurance

The sit-up test was set up as a protocol to evaluate muscular endurance. The participants were instructed to lay on the floor with 90°-knee joint flexion in a supine position. They were then asked to keep their hands at the side of their head with their elbows pointing straight forward to touch their knees, then lean back so that their shoulders would touch the floor. We counted sit-up repetitions in 40 seconds for each participant (Hohmann et al., 2018).

Agility

AAT was applied to assess the ability to change direction over a range of angles and directions. The AAT time was measured using timing gates (Fusion Sport, Coopers Plains, Australia) positioned at the start line. A total of four trials (2-2 attempts to start from left and right, respectively) were completed.

Speed

The 40-m sprint times were recorded using timing gates (SmartSpeed Pro timing lights; Fusion Sport, Coopers Plains, Australia). The photocells were placed at the start and 40 m. Participants were instructed to perform two maximal-effort 40-m sprints using a standing start position and the fastest time was used for analysis.

Balance

The YBT was applied to evaluate dynamic balance. The participants reached out in the anterior, posteromedial, and posterolateral directions with one foot while standing on the other foot on a centralized stance platform. The test was performed barefoot with both the left and right limbs.

Soccer-specific skills

The Loughborough soccer passing test (LSPT) was set to assess the passing performance. Figure 1 presents the LSPT layout. Four wood boards (2.5 × 0.3 m) were placed in the centermost within the 12 × 9.5 m layout. Four differently colored (green, blue, red, and white), 0.6 × 0.3 m sticker pads were attached to the middle of the boards. A 0.1 × 0.15 m thick black line was also taped to the center of the target areas. The participants were requested to respond quickly and accurately by 16 verbal randomized passing orders (Ali et al., 2007). The test sequence consisted of 8 passes including 3.5 meter (4 red and 4 white targets) and 4 meter (4 green and 4 blue targets) passes.

We used the Loughborough soccer shooting test (LSST) to measure the shooting ability. The participants were asked to sprint between two cones of 5.5 meters length from and directly in front of the goal to follow the shot sequence. The shooting zone was an 8.5 × 8.5 m square with a 16.5 m length from the goal line (Figure 2). Each participant completed a single trial of ten shots (5-5 to the right and the left sides, respectively), with a 30-second recovery between each shot order (Stone & Oliver, 2009).
Statistical Analysis

The obtained data were analyzed in terms of means, standard deviation, and multiple linear regression analysis was used to estimate the relative contributions of aerobic capacity, anaerobic performance, power, muscular endurance, balance, speed, and change of direction to specific soccer skills. One-way analysis of variance was used to examine the differences between three positions. The statistical significance was set at a P-value of p < 0.05. All statistical analyses were performed using SPSS version 23.0 for Windows (SPSS Inc Chicago, IL, USA).

Table 1. Multiple regression analysis of anthropometric and physical fitness factors affecting Loughborough soccer passing

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>82.560</td>
<td>31.318</td>
<td></td>
<td>2.636</td>
<td>0.010</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>−0.090</td>
<td>0.138</td>
<td>−0.118</td>
<td>−0.653</td>
<td>0.515</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>0.067</td>
<td>0.141</td>
<td>0.100</td>
<td>0.474</td>
<td>0.637</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>0.031</td>
<td>0.175</td>
<td>0.026</td>
<td>0.177</td>
<td>0.860</td>
</tr>
<tr>
<td>YBT-right leg composite</td>
<td>0.010</td>
<td>0.072</td>
<td>0.024</td>
<td>0.139</td>
<td>0.890</td>
</tr>
<tr>
<td>YBT-left leg composite</td>
<td>−0.054</td>
<td>0.072</td>
<td>−0.124</td>
<td>−0.744</td>
<td>0.459</td>
</tr>
<tr>
<td>Sit-up (reps)</td>
<td>0.171</td>
<td>0.072</td>
<td>0.271</td>
<td>2.383</td>
<td>0.020*</td>
</tr>
<tr>
<td>Arrowhead agility (s)</td>
<td>−0.604</td>
<td>0.699</td>
<td>−0.093</td>
<td>−0.864</td>
<td>0.390</td>
</tr>
<tr>
<td>40-m sprint (s)</td>
<td>−1.055</td>
<td>2.258</td>
<td>−0.058</td>
<td>−0.467</td>
<td>0.642</td>
</tr>
<tr>
<td>CMJ (cm) without arm swing</td>
<td>−0.517</td>
<td>0.213</td>
<td>0.496</td>
<td>−2.428</td>
<td>0.018*</td>
</tr>
<tr>
<td>CMJ (cm) with arm swing</td>
<td>0.449</td>
<td>0.189</td>
<td>0.516</td>
<td>2.376</td>
<td>0.020*</td>
</tr>
<tr>
<td>Drop jump (cm)</td>
<td>0.016</td>
<td>0.097</td>
<td>0.021</td>
<td>0.165</td>
<td>0.870</td>
</tr>
<tr>
<td>Relative maximum power (watt/kg)</td>
<td>−1.615</td>
<td>0.602</td>
<td>−0.545</td>
<td>−2.685</td>
<td>0.009*</td>
</tr>
<tr>
<td>Fatigue index (%)</td>
<td>1.044</td>
<td>0.446</td>
<td>0.446</td>
<td>2.341</td>
<td>0.022*</td>
</tr>
<tr>
<td>VO2max (ml/min/kg)</td>
<td>0.015</td>
<td>0.132</td>
<td>0.012</td>
<td>0.114</td>
<td>0.910</td>
</tr>
</tbody>
</table>

*p < 0.05; YBT = Y-Balance test, CMJ = countermovement jump, VO2max = maximal oxygen uptake

Table 2. Multiple regression analysis of anthropometric and physical fitness factors affecting shooting performance

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>−4.060</td>
<td>4.876</td>
<td>−0.833</td>
<td>0.408</td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>0.019</td>
<td>0.022</td>
<td>0.168</td>
<td>0.833</td>
<td>0.380</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>−0.005</td>
<td>0.022</td>
<td>−0.049</td>
<td>−0.220</td>
<td>0.827</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>−0.007</td>
<td>0.027</td>
<td>−0.039</td>
<td>−0.253</td>
<td>0.801</td>
</tr>
<tr>
<td>YBT-right leg composite</td>
<td>−0.008</td>
<td>0.011</td>
<td>−0.132</td>
<td>−0.720</td>
<td>0.473</td>
</tr>
<tr>
<td>YBT-left leg composite</td>
<td>0.013</td>
<td>0.011</td>
<td>0.204</td>
<td>1.167</td>
<td>0.247</td>
</tr>
<tr>
<td>Sit-up (reps)</td>
<td>0.028</td>
<td>0.011</td>
<td>0.298</td>
<td>2.494</td>
<td>0.015*</td>
</tr>
<tr>
<td>Arrowhead agility (s)</td>
<td>−0.050</td>
<td>0.109</td>
<td>−0.052</td>
<td>−0.457</td>
<td>0.649</td>
</tr>
<tr>
<td>40-m sprint (s)</td>
<td>0.048</td>
<td>0.352</td>
<td>0.018</td>
<td>0.135</td>
<td>0.893</td>
</tr>
<tr>
<td>CMJ(cm) without arm swing</td>
<td>0.058</td>
<td>0.033</td>
<td>0.375</td>
<td>1.749</td>
<td>0.084</td>
</tr>
<tr>
<td>CMJ (cm) with arm swing</td>
<td>−0.025</td>
<td>0.029</td>
<td>−0.198</td>
<td>−0.865</td>
<td>0.390</td>
</tr>
<tr>
<td>Drop jump (cm)</td>
<td>0.001</td>
<td>0.015</td>
<td>0.009</td>
<td>0.067</td>
<td>0.947</td>
</tr>
<tr>
<td>Relative maximum power (watt/kg)</td>
<td>−0.001</td>
<td>0.094</td>
<td>−0.002</td>
<td>−0.007</td>
<td>0.994</td>
</tr>
<tr>
<td>Fatigue index (%)</td>
<td>−0.026</td>
<td>0.069</td>
<td>−0.074</td>
<td>−0.371</td>
<td>0.712</td>
</tr>
<tr>
<td>VO2max (ml/min/kg)</td>
<td>0.023</td>
<td>0.021</td>
<td>0.126</td>
<td>1.139</td>
<td>0.258</td>
</tr>
</tbody>
</table>

*p < 0.05; YBT = Y-Balance test, CMJ = countermovement jump, VO2max = maximal oxygen uptake
statement that the improvement of repeated sprint ability could be used as an effective predictor to enhance shortpassing ability. Therefore, RAST is a useful tool to evaluate anaerobic capacity and predict short-distance performance in intermittent sports (Zagatto et al., 2009; Andrade et al., 2015). Moreover, the physical exhaustion also influences the passing ability. The fatigue index refers to the rate at which power declines for the athlete. These current study results suggest that good players should tolerate the fatigue threshold better and maintain anaerobic performance. Rampinini et al. (2008) discovered that exhaustion caused by short-term high-intensity intermittent actions negatively influenced the short-passing skills of the players. In addition, Mulazimoglu (2016) reported that the fatigue level of the players is an important indicator of their technical competencies. Among these, the degree of individual fitness of the players reportedly correlates with the decline in technical proficiency among players brought on by fatigue. Furthermore, CMJ values were positively linked with passing performance, implying that increasing them all indicates an improvement in the ability to perform an explosive vertical jump. This result was similar to that of a study by Benounis et al. (2013) revealing that the LSPT score performance negatively correlated with squat jump and CMJ performances. Our results facilitate using the CMJ test for talent identification and it could be a protocol to predict young soccer players. In agreement with this, Vantinnen et al. (2010) reported that passing accuracy is related to speed, countermovement jump performance, and coordination in adolescent soccer players. Among these listed characteristics, our study indicates that lower limb explosive strength has been anecdotally linked to passing success. Sit-ups also factor in influencing passing performance, stating that the improvement of repeated sprint ability could be used as an effective predictor to enhance short-passing ability. Therefore, RAST is a useful tool to evaluate anaerobic capacity and predict short-distance performance in intermittent sports (Zagatto et al., 2009; Andrade et al., 2015). Moreover, the physical exhaustion also influences the passing ability. The fatigue index refers to the rate at which power declines for the athlete. These current study results suggest that good players should tolerate the fatigue threshold better and maintain anaerobic performance. Rampinini et al. (2008) discovered that exhaustion caused by short-term high-intensity intermittent actions negatively influenced the short-passing skills of the players. In addition, Mulazimoglu (2016) reported that the fatigue level of the players is an important indicator of their technical competencies. Among these, the degree of individual fitness of the players reportedly correlates with the decline in technical proficiency among players brought on by fatigue. Furthermore, CMJ values were positively linked with passing performance, implying that increasing them all indicates an improvement in the ability to perform an explosive vertical jump. This result was similar to that of a study by Benounis et al. (2013) revealing that the LSPT score performance negatively correlated with squat jump and CMJ performances. Our results facilitate using the CMJ test for talent identification and it could be a protocol to predict young soccer players. In agreement with this, Vantinnen et al. (2010) reported that passing accuracy is related to speed, countermovement jump performance, and coordination in adolescent soccer players. Among these listed characteristics, our study indicates that lower limb explosive strength has been anecdotally linked to passing success. Sit-ups also factor in influencing passing performance,
representing abdominal muscle strength. Core strength is pivotal for stability and movement. The lumbo-pelvic hip complex is crucial for movement control. Core muscles were confirmed to be essential for soccer players as they provide the basis for endurance, posture, strength, power, and coordination, lowering the risk of injury (Chat, 2011). Our results (Table 2) revealed that sit-up significantly affects shooting performance ($p < 0.05$). However, we observed no significant influence exerted by the other independent variables. A critical finding of our results of anthropometric and physical fitness on shooting ability was that the highest significant abdominal strength would be the best predictor of soccer shooting. In contrast, the previous study found that there were no significant correlation between sit-ups with shooting in college soccer players (Poornabodha et al., 2018). Nevertheless, Sun & Shin (2018) reported that pelvic stability could improve shooting speed and accuracy in junior soccer players. Therefore, during the shooting action, core strengthening could support better soccer shooting efficacy. In addition, the comparison between position roles resulted in no significant difference in any parameter, which was in line with the study of Malina et al. (2004) presenting no positional differences among young defender, midfielder, and forward players in vertical jump, sprint time, and intermittent aerobic endurance. Our results also align with a previous study that revealed no significant positional differences in physiological performances including maximal vertical jump height, ball shooting speed, 10- and 30-m sprint times, Yo-Yo IR1, running cost and submaximal running cost, and VO$_{\text{max}}$ (Wong et al., 2009). In the present study, muscular power performance of defenders were higher than midfielders and strikers. The power seems to be a contributor to support defender characteristics as these players require stamina and strength to tackle and jump to prevent the opponents from scoring during their play in a defensive situation. This discovery was in good agreement with the performance characteristics where defenders showed the strongest jump ability. However, these differences were not significant ($p > 0.05$) versus those observed in goalkeepers and strikers (Wik et al., 2018). According to the rationale that no positional difference could be observed in physiological performances, coaches should modify the strength and conditioning regimens appropriately for youth soccer players. In summary, these results can later be used to evaluate the player’s potential and to identify talents in youth soccer players.

**Practical Applications**

Our results established relationships between specific anthropometric as well as physiological characteristics and specific soccer skills which they impact. Although our discoveries underscore the significance of anaerobic performance and core strength endurance indicators, soccer coaches could use the results of this study for identifying young talents for recruiting and developing future top-level players.

**Conclusions**

In our study, we clarified that one of the most important factors in various facets of soccer performance is physical fitness. In particular, players with superior muscular endurance, power, and anaerobic capacity would stand comparatively better chances of being selected for a more advanced or higher-development program in the future, according to talent identification purposes.

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**Conflict of interest**

The authors declare no potential conflict of interest.

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