DOI 10.26773/smj.220606

SportMont

ORIGINAL SCIENTIFIC PAPER

Analysis of Association of the Anthropometric, Motor and Functional Parameters on Competitive Efficiency in Youth Football Players

Jakša Škomrlj[1], Šime Veršić[1], Nikola Foretić[1]

[1]University of Split, Faculty of Kinesiology

Abstract

In a complex team sport setting, such as during a football game, the match's outcome is determined by numerous factors, such as the technical, tactical, physical and psychological preparedness of all the players, who have to act like a unit. This study aimed to identify anthropometric characteristics and motor and functional abilities that affect the competitive efficiency of U-15 football players. A total of 20 football players, classified either as starters (N=10) or non-starters (N=10), underwent morphologic measurements comprising body height and body weight and motoric assessments and testing of functional capacity: 5-meter sprint, 10-meter sprint, 20-meter sprint, broad jump, medicine ball throw, and triple jump on the left and right legs. Additionally, the age of peak height velocity (APHV) was calculated for each participant. The results showed that the body weight (OR:0.86; 95%CI:0.75-0.99) and medicine ball throw (t=2.24; p=0.02) were significant predictors of one's competitive efficiency in the observed sample of young football players. Since upper body power is highly influenced by anthropometric characteristics at this age, starters will most likely receive more playing time and have superiority over their peers due to morphologic advantages. This study once again confirmed that early maturing players have an advantage over others because of their body size, which seems to be a significant determinant of success at that age.

Keywords: *puberty age, competitive efficiency, motor abilities, morphology, maturation*

Introduction

In a complex team sport setting, such as during a football game, the match's outcome is determined by numerous factors, such as the technical, tactical, physical, and psychological preparedness of all the players in a team, who have to act like a unit (Rowat, Fenner, & Unnithan, 2016). The game of football is physically highly demanding and is characterized by a combination of sprint bouts, high-intensity running, tackles, jumps, and turns that can be performed in any direction or plane of motion (Mohr, Krustrup, Nybo, Nielsen, & Bangsbo, 2004; Alexandre et al., 2012). The physiological stress of the match play, which usually lasts around 90 minutes, can be observed through an increase in cardiovascular and metabolic output, rise in core temperature, glycogen depletion, and high energy expenditure (Reilly & Gilbourne, 2003). It is well known that elite-level football players can cover up to 12 km per match and that high-speed running accounts for 1.5-3.3 km of the total distance (Rebelo, Brito, Seabra, Oliveira, & Krustrup, 2014). During the match, average and peak heart rate values are around 85% and 98% of maximal values, respectively, corresponding to an average oxygen uptake of approximately 70% of VO2max (Bangsbo, 2014). Additionally, on average, every 2 to 4 seconds during the match, footballers perform changes of direction, jumps, accelerations, and decelerations, for a total of 1200-1400 of these intensive actions (Sporis, Jukic, Ostojic, & Milanovic, 2009). In recent years, the technical and tactical demands of the game have also increased substantially, likely due to tactical modifications, and as a result, there has been a

Correspondence:

Jakša Škomrlj
University of Split, Faculty of Kinesiology, Teslina 6, 21000 Split, Croatia
E-mail: skomrljj@gmail.com

significant increase in the sprint distance and distance covered in high-speed running (Collins et al., 2021). Due to the outlined specificities of the sport, it is of utmost importance to train and develop players' abilities accordingly so that they can perform these intense actions and recover quickly from these periods of high-intensity exercise (Bangsbo, Mohr, & Krustrup, 2006).

Young football players usually cover 5-7 km during the match, with approximately 15% of the total distance (0.4-1.5 km) including high-intensity activities (Di Giminiani & Visca, 2017). The average heart rate frequency varies between 165 and 171 heartbeats per minute, which corresponds to 85% of maximal heart rate value (Rebelo et al., 2014; Di Giminiani & Visca, 2017). Studies have shown that U-15 players have a similar relative VO2max but poorer running mechanics compared to senior players and that a higher aerobic capacity results in an increase in the total distance covered and high-speed running (HSR) (Stølen, Chamari, Castagna, & Wisløff, 2005; Lovell, Bocking, Fransen, Kempton, & Coutts, 2018). The activity pattern of elite youth and senior football players does not differ much, suggesting that the aerobic capacity and game load of the aforementioned categories are comparable (Strøyer, Hansen, & Klausen, 2004). The anaerobic energy system is crucial when performing explosive activities such as sprinting, jumping, or changing direction, i.e., actions that define key moments of the match (Stølen et al., 2005). An exponential increase in muscle size and power occurs during the pubertal phase, which, combined with carefully planned strength and power training, results in enhanced power-speed abilities manifested in sprints and jumps (Di Giminiani & Visca, 2017). Paul, Gabbett, and Nassis (2016) stated that power, speed, and agility training are necessary for the comprehensive/complete growth and development of young football players. A player's conditional characteristics, such as endurance, strength, and agility, as well as technical and tactical aspects, should be developed for a team's prosperity (Mouloud, 2019).

Previous studies investigating predictors of situational efficiency in youth football showed that young elite players are taller, heavier, more mature, and achieve better results in power, flexibility, and specific football skill parameters (Williams & Reilly, 2000; Malina et al., 2005; Figueiredo, Gonçalves, Coelho E Silva, & Malina, 2009). Ré, Cattuzzo, Santos, and Monteiro (2014) highlight that anthropometric indices, such as body height and body mass - as they have a large influence on the selection of adolescent players - favor biologically advanced individuals. Rowat et al. (2016) indicated that functional capacities and specific football skills are also influenced by maturity status and morphologic components.

Elite players usually perform better in tests of sprints, vertical jumps, and endurance shuttle runs in contrast to average and below-average players (Malina, Ribeiro, Aroso, & Cumming, 2007). This leads to the phenomenon where more mature players, characterized as elite, receive higher-quality coaching and are exposed to increased football-specific loads. The disproportion of these physical and technical loads eventually aggravates or even ceases the developmental path of late-maturing players (Lovell et al., 2018). However, the problem with a sport-selection system that is oriented to physical characteristics emerges at the senior level when these biological distinctions gradually disappear and players are differentiated via specific technical and tactical competencies (Ré et al., 2014).

Given the fact that this phenomenon is still evident in the world of sports in general, particularly in football, the main aim of this study was to identify which anthropometric characteristics and motor and functional abilities affect the situational and competitive efficiency of elite U-15 football players. Rationale of the study was to examine potential distinctions within the morphologic dimensions, and motor and functional abilities of the observed groups. Obtained results could provide us with better understanding of the complex and the multifactorial approach to the squad selection process.

Methods

Participants

The sample included 20 young male football players. Participants were members of a team that competed in the first division of the Croatian national championship and were categorized by the coaching staff either as starters (N=10, on average 14.12 years old), or non-starters (N=10, on average 14.0 years old). The study was conducted at the beginning of the summer preparation period for the 2021/2022. season. All the players were healthy at the time of testing, without evident injury or illness. This study was approved by the Ethics Committee of the Faculty of Kinesiology, University of Split, with approval number 2181-205-02-05-22-004.

Measurements

Variables in this study included anthropometric indices, indirect estimation of the biological age (peak height velocity), and a set of motor and functional variables (sprinting 5, 10, and 20 meters, broad jump, medicine ball throw, unilateral triple jump on both legs, and 30-15 intermittent fitness test).

Anthropometric measurements

Anthropometric measures consisting of body height (BH) and body mass (BM) were recorded. Body mass was measured at 0.1 kg, and body height in cm (encompassing nearest 0.5 cm).

Motor measurements

Acceleration and sprinting abilities were evaluated with the sprint test of 5 meters (5 m), 10 meters (10 m), and 20 meters (20 m) using photoelectric timing gates (Powertimer, New test, Finland). Placed 1 meter behind the starting line, the participant assumed the flying start position and was instructed to start when feeling ready, run as fast as possible, and decelerate after passing the gates. One pair of gates was installed on the starting line, and the second pair was placed 5, 10, and 20 meters away from the starting line, respectively. Lower body power was assessed with the broad jump (BJ), triple jump on the left leg (TJL), and the triple jump on the right leg (TJR). The broad jump test was used to assess the coordination and (horizontal) explosive power of the lower extremities. The participant performed two-legged broad jump without falling forward or moving their feet during landing, and the distance between the starting line and the heel of the back foot was measured. In the triple jump on the left (TJL) and the right leg (TJR), the participant executed 3 maximal consecutive (unilateral) jumps, without pushing off the floor with the other leg, and the distance between the rear heel and the marked line was recorded. The medicine ball throw was used as an indicator of the trunk and upper body power. Holding the 2 kg medicine ball in hands and with feet positioned in parallel stance, athletes performed maximal extension of the body followed by powerful ejection of the medicine ball.

Functional measurements

The 30-15 Intermittent Fitness Test was carried out to estimate aerobic fitness of the players (Buchheit, 2008). The test is performed on a 40-meter-long turf, comprising two alternating periods – 30-second shuttle run and 15-second passive rest. The 30-15 IFT starts at 10 km/h, and the speed gradually increases by 0.5 km/h per level. All tests, excluding 30-15 IFT, were performed twice, with the best result being taken into statistical analysis.

Mirwald, Baxter-Jones, Bailey, and Beunen (2002) algorithm, which calculates age of the peak height velocity (APHV) and maturity offset (DIFF), was used for assessment of biological age.

Statistical analysis

After assessing normality of the distributions using Kolmogorov-Smirnov test, descriptive statistic parameters (arithmetic means and standard deviations) were calculated for all variables. To compare the groups (starter vs. non-starters), Student t-test was used. The differences between starters and non-starters were evaluated by magnitude-based Cohen's effect size (ES) statistics with the following criteria: <0.2 = small magnitude of difference; <0.5 = medium magnitude of difference, and >0.8 = large magnitude of difference. Additionally, to establish associations between predictors (anthropometrics, biological age, motor-functional status) and players' abilities (starters vs. non-starters), binary logistic regression was used. Statistica 13.0 (TIBCO Software Inc, USA) was used for all calculations with a p-level of 95%.

Results

Results of the descriptive statistics (arithmetic means and standard deviations) and Student's T-test (t and p values) are presented in Table 1. Significant differences between starters and non-starters were found in the BM and MT variables. Although the difference is not significant, it can be seen in Table 1 that starters are biologically more mature, entered the APHV period earlier, and have a larger difference between the actual chronological age of APHV.

Table 1. Descriptive statistics and Student t-test

	Group 1		Group 2			
Variable	AM	SD	AM	SD	t-value	p
AGE (years)	14.12	0.33	14.00	0.46	0.67	0.51
APHV (years)	13.30	0.49	13.66	0.56	-1.53	0.14
DIFF (years)	0.82	0.63	0.34	0.72	1.59	0.13
BM (kg)	61.62	7.99	53.67	6.30	2.47	0.02*
BH (cm)	176.25	9.35	170.40	8.28	1.48	0.16
5 m (sec)	1.09	0.06	1.08	0.05	0.19	0.85
10 m (sec)	1.85	0.07	1.82	0.07	1.01	0.33
20 m (sec)	3.21	0.09	3.19	0.09	0.51	0.62
BJ (cm)	2.09	0.11	2.02	0.13	1.26	0.22
MT (cm)	8.91	1.53	7.59	1.06	2.24	0.04*
TJR (m)	6.01	0.38	5.87	0.60	0.65	0.52
TJL (m)	6.03	0.31	5.80	0.55	1.14	0.27
IFT (level)	19.22	1.09	18.88	0.92	0.70	0.49

Legend: AGE – chronological age, APHV – age at peak height velocity, DIFF – difference between AGE and APHV, BM – body mass, BH – body height, 5 m – 5 meters sprint, 10 m – 10 meters sprint, 20 m – 20 meters sprint, BJ – broad jump, MT – medicine ball throw, TJR – triple jump on right leg, TJL – triple jump on left lef, IFT – 30-15 intermittent fitness test

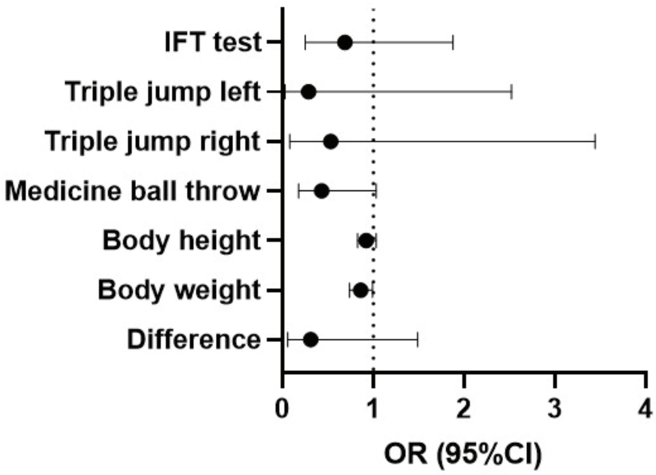

FIGURE 1. Logistic regression results (OR – Odds Ratio, CI – Confidence Interval)

The results of binary logistic regression are graphically presented in Figure 1. It can be seen that the only significant predictor of competitive efficiency was the BM variable.

ES values indicated large magnitude of difference between starters and non-starters in the BM (Cohen's d=1.105) and MT (Cohen's d=1.003) variables.

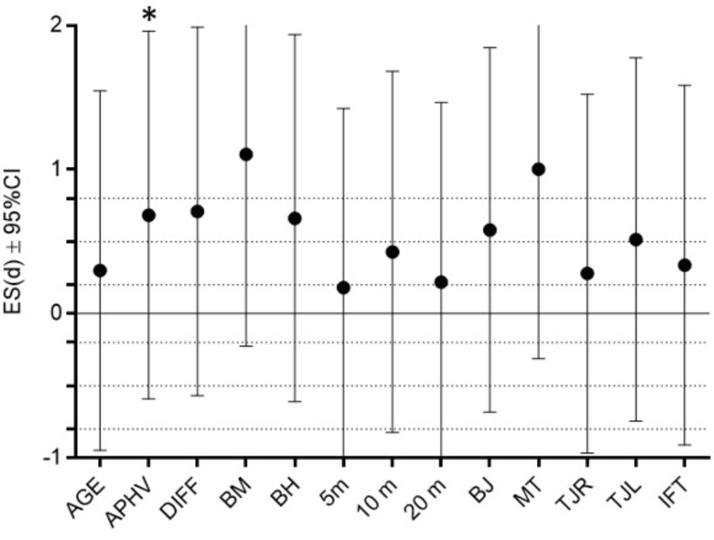

FIGURE 2. Effect Size (ES) differences between observed groups
*APHV variable shows higher values for group 2

Discussion

The results of this study suggest several important findings. First, anthropometric indices (primary body mass) are the factor that differentiates starters and non-starters. Second, there are significant differences in the power of the upper body between the groups.

The results of our analyses suggest that body mass is the most significant factor that contributes to the quality of the players, with starters being heavier than non-starters. To explain such findings, it is important to note that due to higher concentrations of testosterone and growth hormone, boys aged 13-18 experience major weight and height gain, thus enlarging their stature and physical size (Pearson, Naughton, & Torode, 2006). Previous investigations dealing with the body dimensions of youth football players showed that players of higher performance levels are usually biologically more advanced, i.e., they are taller and have a greater body mass in contrast to players of lower performance levels (Rosch et al., 2000; Malina et al., 2005; Malina et al., 2007). These findings are not specific to football only. For example, Gabbett, Kelly, Ralph, and Driscoll (2009) observed an elite junior rugby sample and concluded that starters were heavier and taller than non-starters. Given the fact that our sample is composed of elite young football players, it can be expected that heavier players most likely possess a greater amount of lean body mass (muscle mass). It is well documented that muscle volume directly affects one's ability to produce force, so it seems that players with greater muscle mass are capable of higher force/power production (Sekulic & Metikos, 2007). Although no significant differences in motor variables were observed (except in MT), we can assume that players will exploit this produced force in football-specific activities, such as aerial or ground duels. Therefore, it is reasonable to speculate that coaches will perceive these players as more efficient or successful and give them more playing time.

Furthermore, our results suggest that upper body power (MT) is a significant predictor of the performance level of youth football players. Although intuitively, upper body power does not seem to be a significant factor in football efficiency, this finding can be linked with the already explained difference in body mass. Studies have confirmed that body size and maturity significantly influence the performance of strength and power tests (Malina et al., 2005; Mala, Maly, Zahalka, & Hrasky, 2015). Force production has a regional character and depends on the neuromuscular control, length, and arrangement of the fibers and the muscle cross-section area (Pearson et al., 2006). In a study carried out on an elite sample of Australian football players, Bilsborough et al. (2015) also indicated a high correlation between lean body mass and the manifestation of upper body power. Additionally, for our study, it is important to note that the most significant strength increment in males happens in the adolescent period, between the age of 14 and 16, when gains in muscle size occur due to a higher concentration of androgens (Pearson et al., 2006). The simultaneous development of the nervous system, biochemical properties, and (theoretical) fiber type differentiation happens during the pubertal stage, highlighting the need to improve ballistic movements, such as that evidenced through MT in our study (Kraemer, Fry, Frykman, Conroy, & Hoffman, 1989; Newton, Kraemer, Häkkinen, Humphries, & Murphy, 1996).

Results of the study, conducted on Croatian young footballers from three different age groups (U-15, U-17 and U-19, respectively), indicated significant increase of both absolute and relative VO2 max, reduced heart rate frequencies during submaximal loads, upgraded maximal minute ventilation and advanced breathing economics throughout the older age (Erceg, Rađa, Sporiš & Antonić, 2018). It had been shown that pubescent male football players have 50% less anaerobic capacity compared to their adult counterparts, which could result in a reduced number of sprints and high-intensity running sequences (Nikolaïdis, 2011; Atan, Foskett & Ali, 2016). Herdy et al. (2018) reported lower levels of knee flexion and extension isokinetic strength in U-15 category in contrast to U-17 and U-20 football players (Herdy et al., 2018). Another study revealed that U-15 players performed poorer in SJ and CMJ tests, tests in which lower limb explosive power is estimated, in contrast to U-17 and U-19 category (Sukreški, Krakan & Tomić, 2011).

It is anecdotally known that coaches and scouts often select the players according to their anthropometric-morphological attributes while neglecting smaller players with the same abilities. This approach to talent identification can lead to a premature drop-out of the late-maturing boys who are not included in the training process because of their (relatively) weak stature and (consequently) less-developed motor abilities (Malina et al., 2007; Figueiredo, Coelho e Silva, & Malina, 2011; Ré et al., 2014). Likewise, players labeled as those most talented in puberty usually do not live up to expectations at the senior level, when persistent late-maturing individuals catch up with their body size and strength and power levels (Malina et al., 2007). Some authors propose the idea that the physical inferiority of late-maturing boys can be compensated by improvements in technical and tactical skills that will eventually enhance their perseverance and competitiveness in the game (Vandendriessche et al., 2012). When assembling a team for an important match, most football coaches will most certainly choose the best individuals at that particular moment because of their desire to win. However, such an approach ignores and even obstructs the developmental path of talented, but physically unmatured individuals (Strøyer et al., 2004). Therefore, although players should be selected based on their skills and abilities rather than physical size, in a team that is composed of players of similar football skills, it can be expected that physically larger players will ultimately be chosen to participate more (Williams & Reilly, 2000).

Conclusion

The present study revealed the differences in some anthropometric/morphologic attributes and motor abilities in performance levels among U-15 football players. Namely, starters are heavier and superior in upper body power than non-starters. One of the major strengths of this study was the sample of elite youth football players, as HNK Hajduk is ranked in the top 20 football academies in Europe (CIES, 2021).

Although the sample was relatively homogenous, i.e., composed of equally skilled players, the results indicate that physically advanced players will most likely be selected for the starting squad more frequently, hence receiving more playing time.

In the process of selection, football scouts and coaches usually favor larger players over their weaker teammates because of their perceived robustness, but this is the paradigm that has to be shifted in the future to enable the most talented players to express their football potential, regardless of their stature. Football coaches, especially those working in high-level academies, are constantly pressured to achieve competitive success, which is why they rely more on the larger, physically more dominant players. This is in disagreement with the main goal of the football academy – the production and development of high-quality players.

Conclusions from this study should be interpreted carefully, given the small sample size (N=20). Also, results of this cross-sectional study could be somewhat biased and consequently cannot determine causality link between predictor variables and quality rang.

Future studies should include more objective measures of players' competitive efficiency, such as technical and tactical components of the match that will precisely distinguish between performance levels in high-level football.

Acknowledgments
There are no acknowledgments.

Conflict of Interest
The author declares that there is no conflict of interest.

Received: 21 February 2022 | **Accepted:** 21 May 2022 | **Published:** 01 June 2022

References

Alexandre, D., da Silva, C. D., Hill-Haas, S., Wong, d. P., Natali, A. J., De Lima, J. R., . . . Karim, C. (2012). Heart rate monitoring in soccer: interest and limits during competitive match play and training, practical application. *The Journal of Strength & Conditioning Research, 26*(10), 2890-2906.

Atan, S. A., Foskett, A., & Ali, A. (2016). Motion Analysis of Match Play in New Zealand U13 to U15 Age-Group Soccer Players. Journal of strength and conditioning research, 30(9), 2416–2423.

Bangsbo, J. (2014). Physiological demands of football. *Sports Science Exchange, 27*(125), 1-6.

Bangsbo, J., Mohr, M., & Krustrup, P. (2006). Physical and metabolic demands of training and match-play in the elite football player. *Journal of Sports Sciences, 24*(07), 665-674.

Bilsborough, J. C., Greenway, K. G., Opar, D. A., Livingstone, S. G., Cordy, J. T., Bird, S. R., & Coutts, A. J. (2015). Comparison of anthropometry, upper-body strength, and lower-body power characteristics in different levels of Australian football players. *The Journal of Strength & Conditioning Research, 29*(3), 826-834.

Buchheit, M. (2008). 30-15 Intermittent Fitness Test et répétition de sprints. *Science & Sports, 23*(1), 26-28.

CIES Football Observatory. (2021). *Ajax crowned best training club in Europe.* Retrieved 2/17, 2022, from https://football-observatory.com/IMG/sites/b5wp/2021/wp353/en/

Collins, J., Maughan, R. J., Gleeson, M., Bilsborough, J., Jeukendrup, A., Morton, J. P., ... & Close, G. L. (2021). UEFA expert group statement on nutrition in elite football. Current evidence to inform practical recommendations and guide future research. *British Journal of Sports Medicine, 55*(8), 416-416.

Di Giminiani, R., & Visca, C. (2017). Explosive strength and endurance adaptations in young elite soccer players during two soccer seasons. *PLoS One, 12*(2), e0171734.

Erceg, M., Rađa, A., Sporiš, G., & Antonić, D. (2018). *Functional abilities among young Croatian soccer players*. World Congress of Performance Analysis of Sport XII: Proceedings, 287-293.

Figueiredo, A., Coelho e Silva, M., & Malina, R. (2011). Predictors of functional capacity and skill in youth soccer players. *Scandinavian Journal of Medicine & Science in Sports, 21*(3), 446-454.

Figueiredo, A. J., Gonçalves, C. E., Coelho E Silva, M. J., & Malina, R. M. (2009). Youth soccer players, 11–14 years: maturity, size, function, skill and goal orientation. *Annals of Human Biology, 36*(1), 60-73.

Gabbett, T., Kelly, J., Ralph, S., & Driscoll, D. (2009). Physiological and anthropometric characteristics of junior elite and sub-elite rugby league players, with special reference to starters and non-starters. *Journal of Science and Medicine in Sport, 12*(1), 215-222.

Herdy, C. V., Galvao, P., e Silva, G. C., Ramos, S., Simao, R., Pedrinelli, A., ... & Paschalis, V. (2018). Knee flexion and extension strength in young brazilian soccer players: The effect of age and position. *Human Movement, 19*(3), 23-29.

Kraemer, W. J., Fry, A. C., Frykman, P. N., Conroy, B., & Hoffman, J. (1989). Resistance training and youth. *Pediatric Exercise Science, 1*(4), 336-350.

Lovell, T., Bocking, C., Fransen, J., Kempton, T., & Coutts, A. (2018). Factors affecting physical match activity and skill involvement in youth soccer. *Science and Medicine in Football, 2*(1), 58-65.

Mala, L., Maly, T., Zahalka, F., & Hrasky, P. (2015). Body composition of elite youth soccer players with respect to field position. *Journal of Physical Education and Sport, 15*(4), 678.

Malina, R. M., Cumming, S. P., Kontos, A. P., Eisenmann, J. C., Ribeiro, B., & Aroso, J. (2005). Maturity-associated variation in sport-specific skills of youth soccer players aged 13–15 years. *Journal of Sports Sciences, 23*(5), 515-522.

Malina, R. M., Ribeiro, B., Aroso, J., & Cumming, S. P. (2007). Characteristics of youth soccer players aged 13–15 years classified by skill level. *British Journal of Sports Medicine, 41*(5), 290-295.

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.
Mohr, M., Krustrup, P., Nybo, L., Nielsen, J. J., & Bangsbo, J. (2004). Muscle temperature and sprint performance during soccer matches–beneficial effect of re-warm-up at half-time. *Scandinavian Journal of Medicine & Science in Sports, 14*(3), 156-162.
Mouloud, K. (2019). Level of state anxiety among youth football players according different playing positions. *Sport Mont, 17*(1), 33-37.
Newton, R. U., Kraemer, W. J., Häkkinen, K., Humphries, B. J., & Murphy, A. J. (1996). Kinematics, kinetics, and muscle activation during explosive upper body movements. *Journal of Applied Biomechanics, 12*(1), 31-43.
Nikolaïdis, P. (2011). Anaerobic power across adolescence in soccer players. *Human Movement, 12*(4), 342-347.
Paul, D. J., Gabbett, T. J., & Nassis, G. P. (2016). Agility in team sports: Testing, training and factors affecting performance. *Sports Medicine, 46*(3), 421-442.
Pearson, D., Naughton, G. A., & Torode, M. (2006). Predictability of physiological testing and the role of maturation in talent identification for adolescent team sports. *Journal of Science and Medicine in Sport, 9*(4), 277-287.
Ré, A. H., Cattuzzo, T. M., Santos, F. M., & Monteiro, C. B. (2014). Anthropometric characteristics, field test scores and match-related technical performance in youth indoor soccer players with different playing status. *International Journal of Performance Analysis in Sport, 14*(2), 482-492.
Rebelo, A., Brito, J., Seabra, A., Oliveira, J., & Krustrup, P. (2014). Physical match performance of youth football players in relation to physical capacity. *European Journal of Sport Science, 14*(sup1), S148-S156.
Reilly, T., & Gilbourne, D. (2003). Science and football: a review of applied research in the football codes. *Journal of sports sciences, 21*(9), 693-705.
Rosch, D., Hodgson, R., Peterson, L., Graf-Baumann, T., Junge, A., Chomiak, J., & Dvorak, J. (2000). Assessment and evaluation of football performance. *The American Journal of Sports Medicine, 28*(5_suppl), 29-39.
Rowat, O., Fenner, J., & Unnithan, V. (2016). Technical and physical determinants of soccer match-play performance in elite youth soccer players. *The Journal of Sports Medicine and Physical Fitness, 57*(4), 369-379.
Sekulic, D., & Metikos, D. (2007). *Fundamentals of transformational procedures in kinesiology.* Split: Faculty of natural and mathematical sciences and kinesiology.
Sporis, G., Jukic, I., Ostojic, S. M., & Milanovic, D. (2009). Fitness profiling in soccer: physical and physiologic characteristics of elite players. *The Journal of Strength & Conditioning Research, 23*(7), 1947-1953.
Stølen, T., Chamari, K., Castagna, C., & Wisløff, U. (2005). Physiology of soccer. *Sports Medicine, 35*(6), 501-536.
Strøyer, J., Hansen, L., & Klausen, K. (2004). Physiological profile and activity pattern of young soccer players during match play. *Medicine and Science in Sports and Exercise, 36*(1), 168-174.
Vandendriessche, J. B., Vaeyens, R., Vandorpe, B., Lenoir, M., Lefevre, J., & 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*(15), 1695-1703.
Williams, A. M., & Reilly, T. (2000). Talent identification and development in soccer. *Journal of Sports Sciences, 18*(9), 657-667.