Erdal Arı *
Hasan Sözen

THE RELATIONSHIP BETWEEN ANAEROBIC POWER, REACTION TIME AND BODY COMPOSITION PARAMETERS OF YOUNG SOCCER PLAYERS

ODNOS MED ANAEROBNO MOČJO, REAKCIJSKIM ČASOM IN PARAMETRI SESTAVE TELESA MLADIH NOGOMETAŠEV

ABSTRACT

The anaerobic activities is frequently used in soccer including high intensity actions. The aim of this study was to examine relationships between anaerobic power, reaction times and body composition parameters of young soccer players. The twenty-seven amateur young soccer players (Age: 13.81±0.48 years, height: 166.74±6.16 cm, weight: 55.17±5.40 kg) were involved in study voluntarily. The Wingate anaerobic power test parameters (minimum power, mean power, peak power, fatigue index), dominant and non-dominant hand visual and auditory reaction times and body composition parameters (lean body mass, body fat mass and body fat percent) were examined. The statistical relationships among explored variables were determined by correlation analyze technique. The relationship between parameters was examined by Pearson's correlation coefficient. According to the results, it was found that lean body mass, anaerobic capacity and mean power parameters had a statistical positive correlations ($p < 0.05$). Also, it was found that body fat percent and body fat mass values had a negative correlation with minimum power values ($p<0.05$). There was no significant correlation between visual and auditory reaction time values with body composition and anaerobic power parameters. Consequently, it could be said that the relationship between lean body mass and body fat percent with some anaerobic power parameters could be arisen from similar mechanisms affecting related parameters. Also, it can be concluded that the reaction time parameter is not closely related to the body composition and anaerobic power parameters, as it is closer related to neural mechanisms than physical mechanisms.

Keywords: anaerobic, reaction, body composition, soccer, performance

Ordu University, Physical Education and Sports School, 52200, Ordu, Turkey

Corresponding author:*
Erdal Arı, Physical Education and Sports School, Ordu University, 52200, Ordu, Turkey.
Phone: +905325691852
E-mail: arierdal@hotmail.com

IZVLEČEK

Anaerobni trening se pogosto uporablja v nogometu. Cilj študije je bil preučiti razmerja med anaerobno močjo, reakcijskimi časi in parametri telesne sestave mladih nogometašev. Sedemindvajset amaterskih mladih nogometašev (starost: 13,81 ± 0,48 let, višina: 166,74 ± 6,16 cm, teža: 55,17 ± 5,40 kg) je bilo prostovoljno vključenih v študijo. Preučeni so bili parametri anaerobne moči (minimalna moč, povprečna moč, največja moč, indeks utrujenosti), prevladujoči in nedominantni časi vidnega in slušnega odziva roke ter parametri sestave telesa (mišična masa, maščobna masa in odstotek maščobne mase). Statistična razmerja med raziskanimi spremenljivkami so bila določena s tehniko korelacijske analize. Razmerje med parametri smo preučevali s Pearsonovim koeficientom korelacije. Glede na rezultate smo ugotovili, da so mišična masa, anaerobna zmogljivost in povprečni parametri moči značilno povezani (p <0,05). Ugotovili smo tudi, da so vrednosti odstotkov maščobne in telesne maščobe negativno povezane z najnižjimi vrednostmi moči (p <0,05). Med vrednostmi vizualnega in slušnega reakcijskega časa s telesno sestavo in anaerobnimi parametri moči nismo najdli značilnih korelacij. Sklepamo, da razmerje med mišično maso in odstotki telesne maščobe z nekaterimi anaerobnimi parametri moči izhaja iz podobnih mehanizmov, ki vplivajo na povezane parametre. Prav tako sklepamo, da parameter reakcijskega časa ni tesno povezan s telesno sestavo in parametri anaerobne moči, saj je tesneje povezan z nevronskimi kot fizičnimi mehanizmi.

Ključne besede: anaerobna, reakcija, sestava telesa, nogomet, zmogljivost

INTRODUCTION

Soccer is a sport that incorporates many physical activities. In soccer, endurance is an important performance characteristic as well as strength and power (Stølen, Chamari, Castagna & Wisløff, 2005). Players perform different technical and tactical actions during the game. In a soccer game, running is a dominant activity and sprint, jump, one-to-one contact and ball-kicking activities are important for a successful performance (Cometti, Maffiuletti, Pousson, Chatard & Maffulli, 2001). Also, the actions such as sprint, jump, one-to-one contact, diversion and ball-kicking are explosive and anaerobic activities. These high intensity activities have a key role on game result. High anaerobic power allows players to perform anaerobic activities frequently. Thus, high anaerobic power ability may improve match performance of players. During a 90-minute soccer game, players perform short and explosive activities with short rest intervals (Meckel, Machnai & Eliakim, 2009). These findings highlight the significance of improving anaerobic power in soccer.

Reaction time is an important performance component in physical activities that fast reaction to external stimulus is critical. Reaction time categorized as the visual and auditory reaction time depends on the speed of the connection between motor and sensory neurons (Ricotti, Rigosa, Niosi & Menciassi, 2013). Soccer players have to react quickly during positions with or without ball in game. The better visual and auditory reaction performance can give soccer players an advantage for successful execution of soccer specific actions during game. For performing the requirements of playing positions, players should use the visual and auditory reaction features effectively to observe their opponents and react to them quickly and to carry out necessary actions. It was found that professional and college adolescent soccer players have better complex reaction times than regional adolescent players (Hirose, 2011). This result shows the significance of reaction time and its association with performance in soccer.

Lean body mass positively affects sport performance. Jaric (2002) reports that body mass is closely related to muscle strength. Athletic performance in sports branches depends on body mass and composition. The muscle mass is an important factor affecting lean body mass and motor performance. It could be indicated that the muscle mass is effective on athletic performance in sports branches such as soccer that anaerobic power and motor skills are important. The aim of this study was to examine the relationships between anaerobic power, reaction time and body composition parameters of young soccer players.

METHODS

Participants

The study sample consisted of 27 young soccer players playing in the youth setup of amateur soccer teams (Age: 13.81 ± 0.48 years, training age: 6,14 ± 0,78, height: 166.74 ± 6.16 cm, body weight: 55.17 ± 5.40 kg). The study group was selected from players performing regularly three trainings per week for 1.5 hours in their teams. The players without any sports injury were involved in study. All tests were performed at the same hour of the day with a two-day interval. The study was carried out in accordance with the Helsinki Declaration. The all of players completed the informed consent form and participated in the study voluntarily.

Data Collection

Body Height Measurements

Body height was measured with 0.1 cm precision by a height measuring device (Holtain, Dyfed, England) at upright posture position with barefoot.

Body Weight and Body Composition Measurements

Body weight and lean body mass were measured by a bioimpedance body composition analyzer (BC-418MA, Tanita, Tokyo, Japan). Participants stepped on the analyzer barefoot and grasped the apparatus of device with their hands. The body composition analyzer measured automatically their lean body mass, body fat percentage and body fat mass values.

Measurement of Anaerobic Power Parameters

Anaerobic power parameters of players were measured using the Wingate anaerobic power test performed on a bicycle ergometer (Monark Ergomedic 894E, Monark, Sweden). The anaerobic power test consists of cycling with maximal effort during 30 seconds with a load of 7.5% of total body weight. Participants were informed about the test. Saddle height was adjusted to each participant. Participants were allowed to warm up for 5 min at 60 rpm on the bicycle ergometer with 50 watts of power. After the warm-up, a 5-minute rest period with active recovery exercises was performed and then test was started. Participants were verbally motivated to reach maximal pedaling and allowed to reach 120 rpm. Then, the load on the pan was automatically lowered by the ergometer. The anaerobic power test was terminated after participants maintained pedaling speed for 30 s. The relative (corresponding to the kilogram of body weight) and absolute values of anaerobic capacity (sum of 6 peak power values in each 5 seconds of test), peak power (the highest of 6 peak power values in each 5 seconds of test), minimum power (the lowest of 6 peak power values in each 5 seconds of test) and mean power (mean of 6 peak power values in each 5 seconds of test) parameters were determined in watts using the software of the bicycle ergometer. Fatigue index indicating percentage decrease in power was also determined using the formula below (İnbar, 1986):

Fatigue Index (%): Maximum power – Minimum power / Maximum power x 100

In the Fatigue Index formula, the 30-sec test period is divided into 6 periods of 5 sec. The highest and lowest power values in any 5-sec period of test were determined as maximum and minimum power values, respectively.

Measurement of Reaction Time

Visual and auditory reaction times were calculated using a visual and auditory reaction measuring device (Moart, Lafayette Instrument, USA) measuring the times of reactions to visual and auditory signals. Participants were informed about the test and then the test was started. The participants touched the buttons on the device with the index fingers of their dominant and non-dominant hands as fast as possible when the visual and audio signals were randomly sent by the device. The visual and auditory reaction test was repeated 3 times for the dominant hand and non-dominant hand, respectively. The auditory reaction test was performed similarly after visual reaction test. Visual and auditory reaction times were determined in milliseconds by the device and converted to seconds. The mean of three test values was calculated as mean test score.

Statistical Analysis

The descriptive statistics of paramaters were presented as mean, standard deviation, minimum and maximum values. The statistical relationship between anaerobic power parameters, reaction time and body composition parameters was examined by correlation analysis. The Spearman and Pearson's correlation coefficients were used for analysis of relationship between variables in accordance with normal distribution of data. The statistic package program for Windows operating system (SPSS 22.0, SPSS Inc, Chicago, USA) was used for data analysis. The significance level of all analyzes was applied as $p < 0.05$.

RESULTS

Table 1. Descriptive Statistics of Anaerobic Power, Reaction Time and Body Composition Paramaters.

		n	x̄	SD	Min.	Max.
Anaerobic Power	Peak power (watt)	27	554.45	134.51	367.52	971.04
	Peak power (watt/kg)	27	10.07	2.34	7.02	19.42
	Anaerobic capacity (watt)	27	412.07	65.21	299.66	499.49
	Anaerobic capacity (watt/kg)	27	7.55	0.85	5.88	8.96
	Mean power (watt)	27	415.77	66.91	299.66	499.49
	Mean power (watt/kg)	27	7.55	0.85	5.88	8.96
	Minimum power (watt)	27	179.47	91.41	-25.99	326.29
	Minimum power (watt/kg)	27	3.31	1.69	-0.51	5.83
	Fatigue Index (%)	27	37.95	13.57	16.38	86.23
Reaction Time	Dominant hand visual reaction time (sec)	27	0.44	0.05	0.35	0.58
	Non-dominant hand visual reaction time (sec)	27	0.41	0.04	0.32	0.49
	Dominant hand auditory reaction time (sec)	27	0.42	0.05	0.33	0.54
	Non-dominant hand auditory reaction time (sec)	27	0.41	0.06	0.31	0.63
Body Composition	Body height (cm)	27	166.74	6.16	153.00	181.00
	Body weight (kg)	27	55.17	5.40	43.60	67.10
	Lean body mass (kg)	27	48.71	4.07	38.70	56.40
	Body fat (kg)	27	6.46	2.40	2.00	12.50
	Body fat percentage (%)	27	11.52	3.63	4.60	18.60

Table 2. Results of Correlation Analysis Between Anaerobic Power and Body Composition Variables.

		Body Height (cm)	Body Weight (kg)	Lean Body Mass (kg)	Body Fat Mass (kg)	Body Fat Percentage (%)
Peak power (watt/kg)	r	0.252	0.111	0.191	-0.074	-0.138
	p	,205	,581	,340	,714	,492
Anaerobic capacity (watt/kg)	r	0.330	0.291	0.413	-0.045	-0.158
	p	,093	,140	,032*	,824	,432
Mean power (watt/kg)	r	0.330	0.291	0.413	-0.045	-0.158
	p	,093	,140	,032*	,824	,432
Minimum power (watt/kg)	r	0.057	-0.159	0.033	-0.414	-0.432

	p	,778	,427	,871	,032*	,024*
Fatigue Index (%)	r	0.240	0.078	0.114	-0.019	-0.075
	p	,228	,700	,571	,926	,710

*p<0.05

Anaerobic capacity and mean power correlated positively with lean body mass while minimum power correlated negatively with body fat mass and body fat percentage ($p<0.05$). There was no statistical significant correlation between the other anaerobic power parameters and body composition parameters.

Table 3. Results of Correlation Analysis Between Anaerobic Power and Reaction Time Parameters.

		Dominant Hand Visual Reaction Time (sec)	**Non-dominant Hand Visual Reaction Time (sec)**	**Dominant Hand Auditory Reaction Time (sec)**	**Non-dominant Hand Auditory Reaction Time (sec)**
Peak power (watt/kg)	r	0.254	0.112	0.057	-0.366
	p	,201	,579	,778	,060
Anaerobic capacity (watt/kg)	r	0.240	-0.074	-0.181	-0.094
	p	,229	,713	,365	,642
Mean power (watt/kg)	r	0.240	-0.074	-0.181	-0.094
	p	,229	,713	,365	,642
Minimum power (watt/kg)	r	-0.026	-0.162	-0.233	-0.010
	p	,898	,419	,243	,962
Fatigue Index (%)	r	0.116	0.029	-0.006	-0.248
	p	,566	,886	,978	,212

There was no statistical significant relationship between anaerobic power and reaction time parameters of young soccer players ($p>0.05$). In other words, the anaerobic power parameters didn't correlate with the dominant and non-dominant visual and auditory reaction times.

Table 4. Results of Correlation Analysis Between Reaction Time and Body Composition Parameters.

		Body Height (cm)	Body Weight (kg)	Lean Body Mass (kg)	Body Fat Mass (kg)	Body Fat Percentage (%)
Dominant Hand Visual Reaction Time (sec)	r	-0.151	0.235	0.140	0.290	0.270
	p	,454	,239	,485	,142	,174
Non-dominant Hand Visual Reaction Time (sec)	r	-0.251	0.005	-0.117	0.209	0.246
	p	,207	,982	,561	,296	,216
Dominant Hand Auditory Reaction Time (sec)	r	-0.088	-0.284	-0.265	-0.189	-0.122
	p	,664	,152	,182	,344	,543
Non-dominant Hand Auditory Reaction Time (sec)	r	0.104	-0.045	-0.024	-0.062	-0.062
	p	,604	,822	,906	,758	,759

There was no statistical significant relationship between dominant and non-dominant hand visual and auditory reaction times and body composition parameters.

DISCUSSION

The anaerobic power performance is important in high intensity exercises. The anaerobic power parameters measured during Wingate test indicates anaerobic power and capacity of athletes. Therefore, a lot of studies were available in literature related to anaerobic power and capacity. The visual and auditory reaction time is indicator of neuromuscular performance in exercise. The reaction performance is effective on exercise performance as an element of neuromuscular system. There were a few studies adressed examine relationship between anaerobic power and body composition with reaction time in literature. The examination of relationship between body composition and anaerobic power with reaction time was aimed in this study.

Taheri and Arabameri (2012) reported that sleep deprivation did not affect peak power and mean power parameters. In other words, the authors found no difference in peak power and mean power parameters between sleep-deprived and non-sleep-deprived groups. However, it was reported that the two groups differed by reaction time in mentioned study. Sleep deprivation adversely affects attention and concentration in exercises that the central nervous system is very active. Therefore, it could be said that only the reaction time was differed between the two groups. In our study, no correlation was found between visual and auditory reaction times with body composition and anaerobic power parameters (Table 3 and 4). Considering the activation of the central nervous system on reaction exercise, this result is consistent with findings reported by Taheri and Arabameri (2012).

Nikolaidis (2014) performed a study on female soccer players aged mean 21.7 years and reported that lean body mass and body fat mass parameters correlated highly with peak power and mean power parameters. Also, maximal power parameters were also correlated with lean body mass in mentioned study. Although our study group consisted of young male soccer players, we found similar results indicating that gender has no effect on the correlation between lean body mass and body fat mass with anaerobic power parameters.

Zagatto, Beck and Gobatto (2009) performed a study on 40 young military personnel and reported that 6x35 m repeated sprint test results had a correlation with mean power, peak power and fatigue index. Also, it was found moderately negative correlation between relative and absolute mean power parameters with 35 m. sprint time and between 200 m. sprint time and relative mean power in mentioned study. The repeated sprint test is an exercise based on anaerobic power and athletes with high anaerobic power have better sprint performance due to tolerance to fatigue. We found a correlation between lean body mass and some anaerobic power parameters (Table 2). It is known that lean body mass affects positively anaerobic and explosive exercises. It could be said that lean body mass of participants might have an effect on their anaerobic power parameters and sprint performance although it is not directly addressed in the study of Zagatto, Beck and Gobatto (2009).

Potteiger et al. (2010) performed a study on 21 young male ice hockey players and it was indicated that body fat percentage correlated moderately with some of the skating performance parameters and that skating speed was lower in athletes with a higher body fat percentage. The authors also reported that fast skating correlated moderately with fatigue index and relative peak power at Wingate anaerobic power test. Both ice skating and soccer involve short-term explosive activities, and require well developed anaerobic power abilities. The positive correlation between anaerobic capacity and mean power parameters and lean body mass in our study supports the findings of mentioned study (Table 2).

Nikolaidis (2012) performed a study on young male soccer players and reported that body mass index and body fat percentage correlated negatively with the Wingate test mean power. The findings of mentioned study support results of this study. Both studies found that muscle mass had a positive effect on anaerobic performance. Nikolaidis and Ingebrigsten (2013) performed a study on young and adult handball players and reported that body mass index of adolescent players correlated negatively with active jumping and the Bosco test mean power and correlated positively with fatigue index. Body mass index values greater than ideal values may indicate high body fat percentage affecting negatively the performance of athletes in sports branches requiring anaerobic power. Handball involves anaerobic activities requiring explosive power. Considering that the activities requiring anaerobic power have an effect on performance in soccer, it may be said that the findings of Nikolaidis and Ingebrigsten (2013) are similar to the results of our research.

Sporiš, Jukić, Bok, Vuleta and Harasin (2011) performed a study on 40 maritime military personnel. According to results of mentioned study, it was indicated that body fat percentage correlated moderately and negatively with 5, 10, 20 m. sprint times, active and squat jumping, stride long jump and maximum oxygen consumption. The authors also reported that performance parameters correlated positively with ectomorphic and mesomorphic body type and correlated negatively with endomorphic body type. The positive correlation between lean body mass with anaerobic capacity and mean power parameters in our study (Table 2) is similar to results of their study. Considering that soldiers should have a certain level of physical fitness because of their profession, it might be said that results of mentioned study were similar to findings of our study performed on athletes. In mentioned study, the Wingate anaerobic power test was not performed but sprint and jumping tests requiring anaerobic power were performed. It might be said that the findings of the two studies were similar because of using similar tests requiring anaerobic power.

Nikolaidis et al. (2016) performed a study on soccer players aged mean 23.4 years. They reported that 20 m. sprint time correlated positively with body weight, lean body mass and body fat percentage and correlated negatively with squat and active jumping and Wingate test relative peak and mean power. The author also reported the relationship between lean body mass, body fat percentage, jumping and Wingate anaerobic power with 20 m. sprint performance requiring anaerobic power. This result indicates that low body fat percentage has a positive effect on activities requiring anaerobic power and it is consistent with results of actual study. Heller, Bunc, Buzek, Novotny and Psotta (1995) performed a study on 42 young male soccer players aged mean 16.3 years. The authors reported that lean body mass correlated positively with the Wingate test peak power, anaerobic capacity. It was seen that these findings showed similarity to findings of our study (Table 2).

Andrade et al. (2015) performed a study on 39 young soccer players aged mean16.5 years. The relationship between performance of 30 sec. treadmill anaerobic power test developed by Zemkova and Hamar (2004) and performance of 6x35 meters repeated sprint test used for indirect measurement of anaerobic power was researched in their study. It was reported a positive correlation between the repeated sprint test times and the relative and absolute mean power of the 30 sec. treadmill anaerobic power test in mentioned study. This result indicates that although the ambient conditions were different and the tests were applied in different ways, the physical fitness parameters of exercises requiring anaerobic power may be similar and may correlate with lean body mass and body fat percentage. The correlation between lean body mass and body fat percentage with some anaerobic power parameters was found in our study (Table 2) and this result supported indirectly the findings of Andrade et al. (2015).

Boone, Vaeyens, Steyaert, Bossche and Bourgois (2012) performed a study on 289 Belgian professional soccer players and examined their anthropometric, anaerobic and aerobic performance parameters according to playing positions. They reported that goalkeepers had a higher body fat percentage than other playing positions, higher squat jumping values than right and left fullbacks, and higher active jumping values than right and left fullbacks and midfielders. This result may show that body fat percentage does not have an effect on jumping activities requiring anaerobic power. However, it may be said that goalkeepers execute explosive activities requiring anaerobic power frequently and performance characteristics required for goalkeeping position are more spesific than other playing positions. Therefore, this result may not be consistent with the findings in the literature. The fact that players playing in other positions do not differ by body fat percentage in mentioned study supports this evaluation.

In our study, there was no significant correlation between visual and auditory reaction times with anaerobic power, lean body mass, body fat mass, body fat percentage (Table 3 and 4). The effect on visual and auditory reaction time of neuromuscular performance and central nervous system may have important effect on this result. Anaerobic power parameters indicate the ability to produce high muscle power and maintain it for a certain period of time. In this context, it can be said that the relationship between reaction time and anaerobic power and body composition parameters is not significant statistically because of the structural characteristics of activities. Penna, De Mello, Ferreira, Moraes and Da Costa (2015) divided 76 young male soccer players aged mean 13.36 years into two groups; (1) those born in the first and second quarters of the year and (2) those born in the third and fourth quarters of the year. In mentioned study, it was not found significant correlation between the birth period and the choice reaction time parameter. The birth period is a maturation-related factor. However, birth periods of participants were close to each other in mentioned study and it might be reason of non-significant relationship between the period of birth and reaction time. In our study, it was found that body composition and anaerobic power parameters didn't correlate with reaction time parameters (Table 3 and 4). Body composition and anaerobic power parameters can be defined as maturation-related parameters. However, it was not available a finding regarding maturation in our study. Therefore, it might be concluded that the relationship between two studies was not clearly evaluated. Longitudinal studies should be carried out to reach correct findings on this topic.

Alanazi and Aouadi (2015) performed a study on male soccer players aged mean 24.04 years and reported that reaction time correlated positively with the 20 m. turning sprint and Illinois agility test results. It may be said that anaerobic power may also have an effect on agility according to results of mentioned study. In this aspect, the findings of the mentioned study are similar to those of our study. Karadağ and Kutlu (2006) found that male soccer players aged mean 22.9 years had better non-dominant-foot visual and auditory reaction times than sedentary people. The significant difference between non-dominant foot reaction times of soccer players and sedentary individuals may arise from positive effect of anaerobic and aerobic power exercises performed to soccer players.

Moradi and Esmaeilzadeh (2015) performed a study on a group aged mean 10.7 years and reported that reaction times measured using clinical equipment correlated negatively with body fat percentage and that 4x10 m. agility performence had an effect on clinical reaction times. Reddy, Eckner and Kutcher (2014) performed a study on athletes at different branches and reported that clinical reaction times did not differ according to exercise period. Triki et al. (2012) reported that soccer players aged 10-11 had a lower body fat percentage, higher relative power in squat and active jumping tests and similar relative anaerobic power in Wingate test when compared to judo athletes. These findings indicating positive effect on anaerobic power of low body fat percentage support results of our study. Studies in literature report different results on reaction time. However, the number of studies reporting accurate findings on the correlation between reaction time with body composition and anaerobic power parameters is limited.

CONCLUSION

The examination of relationships between anaerobic power and body composition and reaction time parameters was aimed in this study. The findings indicated that some of the anaerobic power parameters (anaerobic capacity, mean power and minimum power) correlated with lean body mass and body fat percentage although visual and auditory reaction times didn't correlate with body composition and anaerobic power parameters. Also, it was found that the high lean body mass and low body fat percentage affected positively anaerobic power. The results indicated that reaction time might not relate to anaerobic power and body composition parameters due to its neuromuscular characteristic.

Declaration of Conflicting Interests

The authors declare that they have no conflict of interest.

REFERENCES

Alanazi, H.M.N., & Aouadi, R. (2015). Reaction time as a predictor for change-of-direction speed in male soccer players. *Saudi Journal of Sports Medicine*, 15(3), 220.

Andrade, V.L., Zagatto, A.M., Kalva-Filho, C.A., Mendes, O.C., Gobatto, C.A., Campos, E.Z., & Papoti, M. (2015). Running-based anaerobic sprint test as a procedure to evaluate anaerobic power. *International Journal of Sports Medicine*, 36(14), 1156-1162.

Boone, J., Vaeyens, R., Steyaert, A., Bossche, L.V., & Bourgois, J. (2012). Physical fitness of elite Belgian soccer players by player position. *The Journal of Strength and Conditioning Research*, 26(8), 2051-2057.

Cometti, G., Maffiuletti, N.A., Pousson, M., Chatard, J.C., & Maffulli, N. (2001). Isokinetic strength and anaerobic power of elite, subelite and amateur French soccer players. *International Journal of Sports Medicine*, 22(01), 45-51.

Heller, J., Bunc, V., Buzek, M., Novotny, J., & Psotta, R. (1995). Anaerobic power and capacity in young and adult football (soccer) players. *Acta Universitatis Carolinae. Kinanthropologica*, 31(1), 73-83.

Hirose, N. (2011). Prediction of talent in youth soccer players: Prospective study over 4-6 years. *Football Science*, 8, 1-7.

Inbar, O., Bar-Or, O., & Skinner, J.S. (1996). *The Wingate Anaerobic Test*. Champaign:IL: Human Kinetics.

Jaric, S. (2002). Muscle strength testing. *Sports Medicine*, 32(10), 615-631.

Karadağ, A., & Kutlu, M. (2006). Effects of long term soccer training on visual and auditory reaction time of dominant and non-dominant leg in footballers. *Fırat Medical Journal*, 11(1): 26-29.

Meckel, Y., Machnai, O., & Eliakim, A. (2009). Relationship among repeated sprint tests, aerobic fitness, and anaerobic fitness in elite adolescent soccer players. *The Journal of Strength and Conditioning Research*, 23(1), 163-169.

Moradi, A., & Esmaeilzadeh, S. (2015). Association between reaction time, speed and agility in schoolboys. *Sport Sciences for Health*, 11(3), 251-256.

Nikolaidis, P.T. (2012). Elevated body mass index and body fat percentage are associated with decreased physical fitness in soccer players aged 12–14 years. *Asian Journal of Sports Medicine*, 3(3), 168.

Nikolaidis, P.T., & Ingebrigtsen, J. (2013). The relationship between body mass index and physical fitness in adolescent and adult male team handball players. *Indian Journal of Physiology and Pharmacology*, 57(4), 361-371.

Nikolaidis, P.T. (2014). Weight status and physical fitness in female soccer players: Is there an optimal BMI?. *Sport Sciences for Health*, 10(1), 41-48.

Nikolaidis, P.T., Ruano, M.A.G., De Oliveira, N.C., Portes, L.A., Freiwald, J., Leprêtre, P.M., & Knechtle, B. (2016). Who runs the fastest? Anthropometric and physiological correlates of 20 m sprint performance in male soccer players. *Research in Sports Medicine*, 24(4), 341-351.

Penna, E. M., De Mello, M.T., Ferreira, R.M., Moraes, L.C.C.D.A., & Da Costa, V.T. (2015). Relative age effect on the reaction time of soccer players under 13 years old. *Motriz: Revista De Educação Física*, 21(2), 194-199.

Potteiger, J.A., Smith, D.L., Maier, M.L., & Foster, T.S. (2010). Relationship between body composition, leg strength, anaerobic power, and on-ice skating performance in division I men's hockey athletes. *The Journal of Strength and Conditioning Research*, 24(7), 1755-1762.

Reddy, S., Eckner, J.T., & Kutcher, J.S. (2014). Effect of acute exercise on clinically measured reaction time in collegiate athletes. *Medicine and Science in Sports and Exercise*, 46(3), 429.

Ricotti, L., Rigosa, J., Niosi, A., & Menciassi, A. (2013). Analysis of balance, rapidity, force and reaction times of soccer players at different levels of competition. *PloS One*, 8(10), e77264.

Sporiš, G., Jukić, I., Bok, D., Vuleta Jr.D., & Harasin, D. (2011). Impact of body composition on performance in fitness tests among personnel of the Croatian navy. *Collegium Antropologicum*, 35(2), 335-339.

Stølen, T., Chamari, K., Castagna, C., & Wisløff, U. (2005). Physiology of soccer. *Sports Medicine*, 35(6), 501-536.

Taheri, M., & Arabameri, E. (2012). The effect of sleep deprivation on choice reaction time and anaerobic power of college student athletes. *Asian Journal of Sports Medicine*, 3(1), 15.

Triki, M., Rebai, H., Abroug, T., Masmoudi, K., Fellmann, N., Zouari, N., & Tabka, Z. (2012). Comparative study of body composition and anaerobic performance between football and judo groups. *Science and Sports*, 27(5), 293-299.

Zagatto, A.M., Beck, W.R., & Gobatto, C.A. (2009). Validity of the running anaerobic sprint test for assessing anaerobic power and predicting short-distance performances. *The Journal of Strength and Conditioning Research*, 23(6), 1820-1827.

Zemková, E., & Hamar, D. (2004). “All-Out” tethered running as an alternative to Wingate anaerobic test. *Kinesiology: International Journal of Fundamental and Applied Kinesiology*, 36(2), 165-172.