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Variation of physical characteristics, aerobic and anaerobic powers depending on sprinting ability of recreational athletes#

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ABSTRACT

The appropriateness of training goals is important in single session of combined training. Thus, this study aimed to investigate the variations of physical characteristics, aerobic and anaerobic powers depending on sprint speed level (SSL) in recreational male and female athletes. This study consisted of a total of 586 young adults including 424 males and 162 females. A 12 minutes run test for aerobic power, vertical jump test for anaerobic power, 100 meter sprints, body height, body weight, and anthropometric measurements including trunk and leg length were taken respectively. This study showed that the 90th percentile sprint speed male group (NPSSG) is younger, taller, heavier and longer legged than the others while female NPSSG is younger, longer legged and lower trunk/leg length ratio than the other athletes (OA). Male NPSSG had the slightly lower maximum VO_2 value than the OA. In contrast, female NPSSG had higher VO_2max than OA. Similarly, male and female NPSSG with higher vertical jump score had a higher anaerobic power than OA. SSL was negatively correlated with aerobic power in males while SSL was positively correlated with aerobic power in females. Clearly, SSL were not only significantly correlated with the vertical jump score but also with anaerobic power as well as leg length in both genders. It can be concluded that the physical fitness profile differentiated depending on SSL in male and female athletes. There are positive correlations between anaerobic performance and SSL in both genders, and a positive correlation in females and negative correlation in males were observed between SSL and aerobic power.

Keywords: Aerobic power, anaerobic power, sprint speed, vertical jump, anthropometry.

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INTRODUCTION

Physical fitness is the ability of the organism to sustain the homeostasis as closely as possible to the resting state during exercises and competition requiring great effort and to restore it immediately during and after exercise and competition (Chawla et al., 2007). There are numerous studies investigating relationships among the physical fitness components including maximal oxygen uptake and sprints speed, anaerobic power and anthropometric characteristics (Vescovi and McGuigan, 2008; Yamamoto et al., 2008; Ziyagil et al., 2016; Gillen et al., 2016).

Moreover, understanding level of association between aerobic and anaerobic performance can make possible to coaches the capability to evaluate the aerobic power with short-term effort during the talent detection and training because to evaluate the aerobic power during training and talent identification needs much effort and a long recovery time for athletes.

The direct measurement of VO_2max requires sophisticated equipment and qualified labour to conduct the tests while the indirect methods of estimating VO_2max are preferentially used in large population. Due to the limited time and costs, the direct measurement of VO_2max is also not useful in assessment of athlete performance during talent identification and training. It was reported that training at or little above the anaerobic threshold intensity improves both the aerobic capacity and anaerobic threshold level. This intensity of an exercises is greatly correlated with distance running performance and even training at or a little above this intensity is efficient in enhancement of anaerobic threshold not only in elite athletes, but also in sedentary people (Ghosh, 2004). The very short maximal effort can be feasible in the prediction of the aerobic power as practical alternatives to the assessment of aerobic power instead of the laboratory or field tests. Weston et al. (2009) found that the fastest 40-m sprints of soccer referees were related to total distance covered during the match. This can be evaluated as an indirect indicator of aerobic performance. Also, it was suggested that the use of peak speed itself, rather than the estimated maximum oxygen uptake, could be an integrated measure of aerobic performance, concurrently accounting for both running economy and aerobic power (Noakes, 1988). Nikolaidis and Ingebrigtsen (2013) examined the relationship between elevated body mass index (BMI) and selected physical fitness variables including physical working capacity, handgrip strength, anaerobic power and flexibility. They indicated that elevated BMI is more strongly inversely related to physical fitness in adolescent compared to adult handball players. Also, Kalyanshetti and Veluru (2017) investigated the association of BMI and VO_2 max by non-exercise test in medical students. In this research, BMI was negatively and strongly correlated with VO_2 max. So, elevated BMI reduced the person's cardiovascular fitness. On the other hand, anthropometry is defined as the application of a series of measurements on the body that investigates the relationship between anatomical features and movement, and makes performance estimates by creating various indexes and body composition estimates using directly collected data (Gambetta, 1991). It was stated that maximum running velocity of elite sprinters depends on the optimal stride length and stride frequency in the distance between 30 and 60 m (Gambetta, 1991). Also, Baro et al. (2017) concluded that there are slight positive correlation among explosive leg strength, leg length and sprinting speed.

Obviously, investigating the interaction of speed, aerobic and anaerobic power components with anthropometric variables makes possible to understand the similarities and differences in physical fitness profiles between talented and average athletes in both genders. Thus, this study aims to find the variations of physical characteristics, aerobic and anaerobic powers depending on sprint speed level of recreational male and female athletes.

METHODS

Participants and selected measurements

Data were collected from total of 586 young adults including 424 males and 162 females. Mean age, body weight and VO_2max of participants were 19.81 ± 1.86 years, 173.67 ± 5.49 cm, 65.26 ± 6.13 kg and 59.94 ± 3.30 $ml{\cdot}min^{-1}{\cdot}kg^{-1}$, respectively. All of them have been engaging in different sports at recreational level.

For determination of predominant physical fitness and anthropometric components with respect to athletes' sprinting ability in this study, male and female participants were separately ranked from the highest average speed to the lowest, and the fastest 10% was accepted as a talented athletes. Participants were divided into two groups depending on their mean sprinting speed levels (SSL); first level fall under 90^{th} percentile (OA) and second level was on the 90^{th} percentile (NPSSG). The ninety percentile means the average sprint speed of a group is higher than ninety percent of all participants in terms of average sprint speed.

For the purpose of this study, physical fitness components including a 12 minutes run test for aerobic power, vertical jump for anaerobic power and 100 meter sprints for speed were tested. Also, anthropometric characteristics including body height and weight, trunk and leg length were measured.

Measurement of body height and weight

Measurements of body weight and height of the participants were taken in standing position with wearing shorts and T-shirt without shoes before breakfast. Body weight was measured in kilograms to the nearest 0.1 kg using a Seca™ digital weighing scale (Seca, Germany). Body height was measured in centimeters to the nearest 0.1 cm using a metal stick of this scale.

Calculation of BMI

BMI was calculated using the following formula: weight (kg) divided by height (m) squared.

Leg and trunk length measurements

Leg length was measured as the distance between the floor and the coccyx while standing without shoes. Trunk length was calculated as the difference between body height and leg length (Verducci, 1980).

Vertical jump and calculation of anaerobic power

Sargeant jump test was used to evaluate jump height (cm) of the subjects. The participant warms up for 10 minutes and chalks the end of his/her fingertips. The participant stands side onto the wall, keeping both feet remaining on the ground, reaches up as high as possible with one hand and marks the wall with the tips of the fingers (M1). The participant from the stationary position jumps as high as possible and marks the wall with the chalk on his fingers (M2). Then the distance between M1 and M2 was measured and jumping height was calculated. The best value of two trials was recorded as vertical jump height (Tamer, 2000).

The athlete's anaerobic power was calculated by following formula:

P (kg.m.sec. = $\sqrt{}$ 4.9 × body weight (kg) × $\sqrt{}$ jump height (m)).

During the jump, an approach step was not allowed. A 30 to 60 s rest period was given between trials (Fox et al., 1988).

100 m speed and calculation of mean sprinting speed

After a standardized 15-min warm-up including walking, jogging, several acceleration runs, and ballistic stretching exercises, the participants underwent a sprint test that consisted of two maximal 100 m sprints with a three minutes rest period between each trial. The average speed (AS) is determined by the running time divided by the running distance (AS = m/sec).

12 minutes run test and calculation of VO_2max

Participants completed the Cooper 12 minute run fitness test. Total distance covered by each participant in 12 minutes test was recorded by observers. The objective of the test was to run or walk as much as you can in the 12-minute period. With the obtained result, VO_2max level was determined using the following formula (Cooper, 1968):

VO_2max ($ml.kg^{-1}.min^{-1}$) = (22.351 × distance covered in kilometres) - 11.288.

Statistical analyses

Descriptive statistics were presented as means and standard deviations according for two groups including NPSSG and others. The assumption of normality was not verified using the Kolmogorov Smirnov test. Non-parametric Mann Whitney U tests were used for comparison of two groups. Also, Spearman rank order correlation coefficients were calculated to determine the correlation level between the variables. The alpha level of statistical significance was set at $p < 0.05$ for all statistical tests.

RESULTS

Comparison of physical fitness and anthropometric characteristics, between 90th percentile male sprinters and others was presented in Table 1, while Table 2 shows the comparison of physical fitness and anthropometric characteristics, between 90th percentile female sprinters and others.

Spearman rank order correlation coefficients of mean sprint speed level with physical fitness and anthropometric characteristics in male and female participants was presented in Table 3.

DISCUSSION

The understanding of interrelation of physical fitness components can help the coaches not only to focus on enhancing the bioenergetics profile for their sporting event but also to design the effective combined aerobic and anaerobic trainings as well as to evaluate the aerobic power with short-term and easy effort during the talent detection (Gillen et al., 2016; Bompa and Buzzichelli, 2019). The appropriate combination of training goals is important in single session of concurrent training because weight lifts, speed, plyometrics, agility and coordination exercises in many sports branches, are carried out together with aerobic training. Thus, it seems to be necessary to understand of different physiological adaptations and to design effective training programs related to combine aerobic and anaerobic training of athletes at different levels (Gillen et al., 2016). Gantois et al. (2018) aimed to verify if the change in maximum oxygen uptake is related to the improvement of repeated sprints ability after six weeks of training during preseason. They reported that 7.5% increase in the maximum oxygen uptake of basketball players after six weeks of repeated sprints training. In addition to routine technical-tactical training during preseason, Gantois et al. (2018) also demonstrated the appropriateness of training goals related aerobic and anaerobic powers in single session of concurrent training. Research has shown that endurance athletes practicing resistance training tend to have a more effective economy and therefore less energy expenditure during running (Yamamoto et al., 2008). It was estimated that the sprint test scores would be related to distance covered at high-intensity running and it means that athlete with higher sprints speed can have higher performance at distance running than athlete with lower sprint speed since athlete with higher running speed can run with the lower percentage of his/her maximal effort at the real competition running pace (Weston et al., 2009). Thus, maximal sprinting speed of

Table 1. Comparison of physical fitness and anthropometric characteristics between 90th percentile male NPSSG and others (OA).

Variables	Sprint speed levels	N	Mean	S.D.	Diff.	% Diff.	MWU test	z	Asymp. Sig.
Age (years)	NPSSG	50	19.38	1.87	0.49	2.47	7646.5	-2.125	.034*
	OA	374	19.87	1.85					
	Total	424	19.81	1.86					
Body height (cm)	NPSSG	50	175.88	4.84	2.51	1.43	6912.5	-3.001	.003**
	OA	374	173.37	5.51					
	Total	424	173.67	5.49					
Body weight (kg)	NPSSG	50	67.64	5.09	2.7	3.99	6574.5	-3.417	.001**
	OA	374	64.94	6.19					
	Total	424	65.26	6.13					
BMI (kg/m^2)	NPSSG	50	21.86	1.23	0.28	1.28	8165.5	-1.456	.146
	OA	374	21.58	1.52					
	Total	424	21.62	1.49					
Leg length (cm)	NPSSG	50	94.64	3.27	1.54	1.63	7205.5	-2.643	.008**
	OA	374	93.10	4.38					
	Total	424	93.28	4.29					
Trunk length (cm)	NPSSG	50	81.24	3.89	0.97	1.19	8033.5	-1.623	.105
	OA	374	80.27	3.88					
	Total	424	80.38	3.89					
Trunk/leg length ratio	NPSSG	50	.86	.053	0	0.00	8996.0	-.435	.664
	OA	374	.86	.060					
	Total	424	.86	.061					
12 minutes run test (m)	NPSSG	50	3347.04	161.41	44.87	1.32	6516.0	-3.483	.000**
	OA	374	3391.91	201.69					
	Total	424	3386.62	197.74					
Max. VO_2 ($ml.kg.min^{-1}$)	NPSSG	50	59.28	2.69	0.75	1.25	6516.0	-3.483	.000**
	OA	374	60.03	3.36					
	Total	424	59.94	3.30					
100 meter sprint run (sec)	NPSSG	50	12.22	0.21	1.04	7.84	.00	-11.490	.000**
	OA	374	13.26	0.56					
	Total	424	13.14	0.62					
Mean sprint speed in100 m (m/sec)	NPSSG	50	8.18	0.14	0.62	7.58	.00	-11.490	.000**
	OA	374	7.56	0.30					
	Total	424	7.63	0.35					
Vertical jump (cm)	NPSSG	50	51.02	5.23	4.45	8.72	5443.0	-4.810	.000**
	OA	374	46.57	6.44					
	Total	424	47.10	6.46					
Anaerobic power ($kg.m.sec^{-1}$)	NPSSG	50	129.74	7.72	8.5	6.55	4648.0	-5.778	.000**
	OA	374	121.24	10.76					
	Total	424	122.24	10.79					

*P < 0.05. **p < 0.01. MWU = Mann Whitney U Test.

Table 2. Comparison of physical fitness and anthropometric characteristics between 90th percentile female NPSSG and others (OA).

Variables	Sprint speed levels	N	Mean	S.D.	Diff.	% Diff.	MWU test	z	Asymp. Sig.
Age (years)	NPSSG	17	18.00	1.37					
	OA	145	19.14	1.91	1.14	5.96	792.5	-2.456	.014*
	Total	162	19.02	1.89					
Body height (cm)	NPSSG	17	162.59	5.43					
	OA	145	162.49	5.28	0.1	0.06	1223.5	-.049	.961
	Total	162	162.50	5.28					
Body weight (kg)	NPSSG	17	53.24	3.83					
	OA	145	53.71	5.65	0.47	0.88	1178.0	-.298	.765
	Total	162	53.66	5.48					
BMI (kg/m^2)	NPSSG	17	20.13	0.99					
	OA	145	20.32	1.69	0.19	0.94	1186.5	-.251	.801
	Total	162	20.30	1.63					
Leg length (cm)	NPSSG	17	85.35	4.08					
	OA	145	83.21	3.29	2.14	2.51	858.5	-2.059	.039*
	Total	162	83.44	3.43					
Trunk length (cm)	NPSSG	17	77.24	3.96					
	OA	145	79.28	4.36	6.2	7.43	942.0	-1.593	.111
	Total	162	79.06	4.36					
Trunk/leg length ratio	NPSSG	17	.91	.067					
	OA	145	.95	.067	0.22	0.28	785.5	-2.444	.015*
	Total	162	.95	.068					
12 minutes run test (m)	NPSSG	17	2796.59	136.33					
	OA	145	2540.37	181.10	256.22	9.16	329.0	-4.938	.000**
	Total	162	2567.26	193.35					
Max. VO_2 ($ml.kg.min^{-1}$)	NPSSG	17	50.11	2.27					
	OA	145	45.84	3.02	4.27	8.52	329.0	-4.938	.000**
	Total	162	46.29	3.22					
100 meter sprint run (sec)	NPSSG	17	15.10	0.46					
	OA	145	17.25	0.99	2.15	12.46	.00	-6.736	.000**
	Total	162	17.02	1.15					
Mean sprint speed in 100 m (m/sec)	NPSSG	17	6.63	0.21					
	OA	145	5.82	0.32	0.81	12.22	.00	-6.737	.000**
	Total	162	5.90	0.40					
Vertical jump (cm)	NPSSG	17	40.06	4.66					
	OA	145	33.21	4.98	6.85	17.10	329.0	-4.952	.000**
	Total	162	33.93	5.36					
Anaerobic power ($kg.m.sec^{-1}$)	NPSSG	17	101.91	6.34					
	OA	145	93.13	8.91	8.78	8.62	498.5	-4.012	.000**
	Total	162	94.06	9.07					

* $P < 0.05$. ** $p < 0.01$. MWU = Mann Whitney U Test.

Table 3. Spearman rank order correlation coefficients of sprint speed level with physical fitness and anthropometric characteristics in male and female participants.

Variables	Sprint speed level‡	
	Male	Female
12 minutes run	-.169**	.389**
Max.VO_2	-.169**	.389**
Vertical jump	.234**	.390**
Anaerobic power	.281**	.316**
Body height	146**	-.004
Body weight	166**	.024
BMI	.071	.020
Leg length	.128**	.162*
Trunk length	-.079	.126
Trunk/leg length ratio	.021	.193*

‡Sprint Speed Level (SSL) for sum of OA + NPSSG. *P < 0.05. **p < 0.01.

an athlete could play an important role in the determination of his or her effort level during competition (Weston et al., 2009; Ziyagil et al., 2016). In addition, explosive-high intensity exercises may be effective at decreasing ground contact time during running via improving the stretch-shortening cycle. So this can lead to an improvement in aerobic running performance (Jung, 2003). Thus, the findings of this study clearly showed that the variations of physical characteristics, aerobic and anaerobic powers depend on sprint speed level (SSL) in recreational athletes.

In our study, the 90th percentile sprint speed male group (NPSSG) is younger, taller, heavier and longer legged than the other athletes (OA). NPSSG covered slightly lower distance than OA in 12 minutes run test. So, male NPSSG had slightly lower VO_2max than OA. On the other hand, Male NPSSG with mean value of higher body weight and jump score had a higher anaerobic power than other athletes.

In females NPSSG is younger, longer legged and lower trunk/leg length ratio than OA. Contrary to male group, female NPSSG covered higher distance than OA in 12 minutes run test. So, female NPSSG had higher max VO_2 than OA. On the other hand, male and female NPSSG with mean value of their higher body weight had a higher anaerobic power than other athletes. These differences in male and females can be best explained by sexual dimorphism. It expresses differences in body size and shape between male and female. These structural differences were appeared mainly in the adolescent period. So, it causes male to have a larger body structure than female and adult male is 7% taller than female (Kirchengast, 2010). In addition, one of the reasons why the NPSSG group in females only has high aerobic power than other athletes can be explained by differences in body muscle mass due to the low participation rate of female OA in intense and regular sports activities in Turkey. Exercise induced differences in total body muscle mass are large and are cause to differentiate in aerobic performance in females. Generally, male NPSSG and OA have higher participation rates in intense and regular sports activities than females. Thus, exercise induced differences in total body muscle mass are smaller and are not cause to differentiate in aerobic performance in males (Kirchengast, 2010; Maciejczyk et al., 2014). However, there is no attempt to conduct a comprehensive analysis of the influence of anthropometric on aerobic performance. The influence of body composition may be particularly important for sports disciplines of basketball, boxing, or handball in which athletes are required to have an appropriately high aerobic performance together with high muscle mass (Maciejczyk et al., 2014).

Results of this study for male NPSS group were inconsistent with the results of several researchers compared to consistent results of female NPSS group with them (Noakes, 1988; Rampinini et al., 2007; Vescovi and McGuigan, 2008; Yamamoto et al., 2008; Baro et al. 2017).

Our results support the idea that SSL requires high anaerobic power (Vandewalle et al., 1987) because there were significant positive correlations between SSL and anaerobic power in both genders in this study. Similar results were not observed between SSL and aerobic power in both males and females because SSL correlates negatively with aerobic power in males while it shows positive correlation with aerobic power in females. It was also reported that the relationship between aerobic power and anaerobic power output is the common to most sports, there was no inter-correlation in any measurement between aerobic and anaerobic power values (Tanaka et al., 1993). In another study, a negative correlation was found between VO_2max and peak anaerobic power output in trained men (Katch and

Weltman, 1979). Similar to the relationship we found for male in our study, Katch and Weltman (1979) reported a negative correlation between VO_2 max and peak anaerobic power output in trained males. Moreover, a negative correlation was found between aerobic power and anaerobic power among sprint, middle-distance, and endurance runners (Crielaard and Pimay, 1981).

On the contrary to our results, there were positive correlations in untrained participants between these measurements (Boulay et al., 1985). Jones and McCartney (1986) also determined a strong positive relationship (r = 0.92) between aerobic power and the total work in 30 s maximal isokinetic cycling. There were disagreements between these reported studies due to participants' physical and anthropometric characteristics and fitness level.

Male NPSSG had a 1.25% lower VO_2max and 7.58% higher mean sprint speed level than OA. In the same variables, female NPSSG had averages higher 8.52% in maxVO_2 and 12.22% higher than others in mean sprint speed level. For female this may partly explain the relationship of sprint speed with endurance running economy and aerobic power and supports the idea that athlete with higher sprints speed can have higher performance at distance running than athlete with lower sprint speed due to athlete with higher running speed can run with the lower percentage of his/her maximal effort at the real competition running pace. Thus, maximal sprinting speed of an athlete could play an important role in the determination of his or her effort level during competition (Weston et al., 2009; Ziyagil et al., 2016). Also, it was suggested that the use of peak speed itself, rather than the estimated maximum oxygen uptake, could be an integrated measure of aerobic performance, concurrently accounting for both running economy and aerobic power (Noakes, 1988).

Generally, it was observed that SSL showed negative correlation with 12 minutes running and maxVO_2 variables in males. Contrarily, SSL showed significant positive correlations with 12 minutes running and VO_2max variables in females. This shows that gender factor is the main indicator to explain whether correlations are negative and positive among SSL, 12 minutes run and VO_2max. Also, this study showed that male participants with higher sprint speed were younger, taller, heavier and longer legged than the others while female athletes with higher sprint speed are younger, longer legged and lower trunk/leg length ratio than the others. Vertical jump and anaerobic power were significantly correlated with sprint speed level in both genders.

In conclusion of the present study, the relationships among sprint speed, aerobic and anaerobic power can be modulated by gender and anthropometric characteristics of the subjects. The discrepancies between these studies may be partly due to: 1) characteristics of the subject population and 2) adjustments for body size. Studies using more homogeneous groups showed positive correlation among these variables (Tanaka et al., 1993). Thus, it seems to be necessary to understand the different physiological adaptations to design effective training programs related to combine aerobic and anaerobic combined training of athletes at different fitness and development levels (Gillen et al. 2016, Gantois et al. 2018). It can be concluded that the physical fitness profile differentiated depending on SSL in male and female athletes. There are positive correlations between anaerobic performance and SSL in both genders, and a positive correlation in females and negative correlation in males were observed between SSL and aerobic power.

Nevertheless, this issue is still controversial, and additional study on the relationship among sprint speed, aerobic and anaerobic power in top class sprinters is warranted in both genders.

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