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ORIGINAL RESEARCH

GENDER DIFFERENCES IN ANAEROBIC POWER IN PHYSICAL EDUCATION AND SPORT SCIENCE STUDENTS

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SUMMARY
Purpose: To find out gender differences in anaerobic power and capacity in Physical Education and Sport students. Methods: 56 female (age 22.72 years old ± 1.96, body mass 60.7 Kg ± 6.06, stature 1.69 m ± 0.06 and body mass index 21.19 $Kg \cdot m^{-2}$ ± 1.92, mean ± standard deviation) and 152 male students (23.34 years old ± 2.14, 77.3 Kg ± 7.85, 1.82 m ± 0.06 and 23.28 ± 1.93 $Kg \cdot m^{-2}$) realized the Wingate anaerobic test. Results: The male showed significantly higher values in the main indexes of the test, peak power-PP (63.36 % in absolute and 28.03 % in relative to body mass values), mean power-MP (60.76 % in absolute and 26.06 % in relative to body mass values) and fatigue index (8.15 %) with comparison to female students. Female and male students revealed similar and high correlation between body mass and power parameters in absolute values (r=0.79 and r=0.81 for PP and 0.79 and 0.82 for MP, correspondingly). Conclusion: The significant gender differences in anaerobic power support the teaching in separate classes according to gender and it is suggested to consider these quantitative differences in the design of effective study programs. Key Words: Wingate, ergometry, study programs.

INTRODUCTION

In the Faculties of Physical Education and Sport Science (FPESS), a common practice is the teaching of courses regarding sport events and physical abilities in separate classes for female and male students. Gender differences in anthropometric and physiological characteristics justify a distinction like this. Usually students are examined in some activity that involves the use of aerobic and anaerobic mechanism of energy production. The quantitative determination of gender differences in anthropometric and physiological characteristics is closely associated with the effectiveness of Study Programs in these Faculties. However, only a few researches have been realized till now in this field. Therefore, the aim of the present study was to highlight the gender differences in anaerobic power and capacity in FPESS.

Gender differences in anaerobic power are due to differences in body composition, strength and neuromuscular function (Blimkie *et al.*, 1988; Mayhew and Salm, 1990; Mayhew *et al.*, 2001). An important influence was that of body size and especially of body mass. Murphy, Patton and Frederick (1986) found absolute peak and mean power in men to be higher 35 % and 40 % than in women, respectively. In the same study, when the power parameters' differences were expressed in relation to lean body mass decreased to 10 % and 17 %. In another case, gender differences in anaerobic power and capacity were also reduced when data was adjusted for body weight, but when values were given relative to fat free mass there was no significant difference (Maud and Shultz, 1986).

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Fat free mass was the most important explanatory variable of the variance of anaerobic performance in obese and non-obese adolescents and there was no significant difference between girls and boys when fat free mass was taken into account (Duche *et al.*, 2002). Body mass, stature and age were found as significant explanatory variables of both peak and mean power in adolescent girls and boys (Armstrong, Welsman and Chia, 2001).

Gender differences in anaerobic capacity have been investigated with the use of Wingate Anaerobic Test (WAnT; Murphy, Patton and Frederick, 1986; Hill and Smith, 1993; Belotserkovskii *et al.*, 2004; Musa, 2005), Margaria-Kalamen stair run (Mayhew *et al.*, 2001), force – velocity test (Mercier *et al.*, 1992). The Wingate test is considered as a valid mean to assess anaerobic power and capacity, even if the aerobic contribution in the total amount of power during the test has been certified in recent studies (Bediz *et al.*, 1998; Micklewright, Alkhatib and Beneke, 2006).

The most useful indexes of WAnT are peak power, mean power and fatigue index. Peak power (PP) refers to the highest power elicited from the test taken as the average power over any 5 s period. Mean power (MP) is the average power during the 30 s of the test. Peak and mean power can be measured in absolute (W) and relative units ($W \cdot Kg^{-1}$, where Kg refers to body or lean mass). Reliability coefficients in a test-retest situation vary from about 0.90 to about 0.98 for mean and peak power (Bouchard *et al.*, 1991). The WAnT is less reliable tool considering the fatigue index (FI), which is the amount of the decline in power during the test, defined as the difference between peak and minimal power divided by peak power and therefore expressed as a percentage of peak power (% PP).

The WAnT is employed widely in assessing anaerobic power's gender differences; it was used to assess power outputs in a study of lower and upper body anaerobic performance in male and female adolescent, where males had higher ($p<0.001$) absolute peak power (694 W vs. 442 W) and mean power (548 W vs 307 W; Nindl, Mahar, Harman and Patton, 1995). Elsewhere, male wrestlers, members of the Polish Olympic team, had higher peak power (11.4 W/Kg) than female (8.6 W/Kg) and mean power (8.7 W/Kg vs. 6.8 W/Kg) (Hubner-Wozniak, Kosmol, Lutoslawska and Bem, 2004).

METHODS

Participants. Fifty-six female and 152 male FPESS students volunteered as subjects in this study (**Table 1**). Participants were chosen randomly from undergraduate and postgraduate FPESS students. Procedures were explained and oral informed consent was obtained prior to experimentation. The subjects were accustomed to physical exercise and practiced sport and recreational activities, as tennis, cycling, volleyball, ice hockey, track and field, football and skiing.

Table 1. Anthropometric characteristics of the participants in the present study and their comparison.

	Male	Female	Differences (%)	Significance (P)
n	152	56		
Age (years)	23.34 (2.14)	22.72 (1.96)	2.73	*n.s.*
Body mass (Kg)	77.3 (7.85)	60.7 (6.06)	27.35	<0.0005
Height (m)	1.82 (0.06)	1.69 (0.06)	7.69	<0.0005
B.M.I. ($Kg \cdot m^{-2}$)	23.28 (1.93)	21.19 (1.92)	9.86	<0.0005

Values are presented as means with standard deviation in brackets.

Equipment. A wall-mounted stadiometer was used to measure participants' height. A calibrated balance-beam scale was used to measure weight. The latter measurement took place without shoes and in light clothing. The Wingate test was performed on a modified friction loaded ergometer (Monark 824E, Varberg, Sweden). The ergometer was calibrated in a wide range of loads and revolutions.

Experimental protocol. Prior to initiation of the test, the seat height of the bicycle was adjusted to allow for a slight bend in the knee (approximately 170° – 175°) of the subjects while pedaling. Toe clips and straps were used to avoid losing the pedals during cycling. Handlebars were adjusted according to individual preference. The participants were verbally encouraged to maintain as high a pedaling rate as possible, especially during the last seconds of the test, when fatigue was intense and the subject had strong need of motivation.

Data analysis. Regarding the anthropometric parameters, body mass index was calculated as weight in kilograms divided by the square of height in meters ($Kg \cdot m^{-2}$). The standard method of calculating power produced by a participant during Wingate test considered the braking resistance and flywheel velocity in the computations. The comparison between female and male participants' parameters was calculated by the

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equation $x = \frac{y}{z} \cdot 100 - 100$, where x was the result of comparison (%), y the group with higher mean value and z the corresponding mean value of the group with lower value. The duration of every flywheel revolution was measured with the help of electronic sensor and power output of every revolution was computed by specialized software.

Statistical analysis. Means (*M*) and standard deviations (*SD*) were calculated for each power (peak and mean power in absolute and relative values and fatigue index) and anthropometric (age, stature, body mass, body mass index) parameter. The independent *t*-test was used to determine whether female and male students' means differed reliably from each other. Significance was set at $P<0.01$ for all the tests.

RESULTS

The comparison between female and male students revealed statistically significant differences in all the main indexes of WAnT, peak power in absolute and relative to body mass values, mean power in absolute and relative to body mass values, and in fatigue index (**Table 2**). Higher values were achieved by male students for all the aforementioned parameters. These differences were attenuated when values were expressed in relation to body mass. With respect to secondary indexes of WanT, male students had higher minimum power and total number of revolutions than female students, while there was no gender difference in the mean power to peak power ratio (**Table 3**).

Table 2. The results of the main indexes of WAnT.

		Male	Female	Differences (%)	Significance (*P*)
Peak power	W	1045.94 (130.1)	640.27 (75.9)	63.36	<0.001
	$W \cdot Kg^{-1}$	13.52 (1)	10.56 (0.76)	28.03	<0.001
Mean power	W	830.03 (97.53)	516.33 (53.19)	60.76	<0.001
	$W \cdot Kg^{-1}$	10.74 (0.71)	8.52 (0.54)	26.06	<0.001
Fatigue index	%	39.8 (6.59)	36.8 (6.93)	8.15	<0.01

Values are presented as means with the standard deviation in brackets.

Table 3. The results of the secondary indexes of WAnT.

		Male	Female	Differences (%)	Significance (*P*)
Minimum power	W	626.19 (82.49)	401.93 (45.31)	55.8	<0.001
	$W \cdot Kg^{-1}$	8.11 (0.79)	6.64 (0.63)	22.14	<0.001
Mean/Peak power	%	79.56 (4.69)	80.95 (5.27)	-1.75	-
Revolutions		53.4 (3.49)	50.8 (3.2)	5.12	<0.001

Values are presented as means with the standard deviation in brackets.

In addition to body mass, peak anaerobic power and mean power (MP) were also associated with stature and body mass index for both genders (**Table 4**). An age effect was noticed in men regarding relative MP, with lower values in older participants, and in women with respect to fatigue index, with higher values in older female students. Fatigue index was linked to body mass (in women) and to body mass index (in both gender), too.

Table 4. The Pearson product moment correlation (*r*) between WAnT main indexes and anthropometric characteristics in female (F) and male (M) participants.

	Age		Body mass		Stature		Body mass index	
	F	M	F	M	F	M	F	M
PP_{absol}	0.21	0.05	0.79*	0.81*	0.38*	0.44*	0.58*	0.62*
PP_{relat}	0.18	-0.08	-0.08	-0.03	-0.12	-0.06	0.03	0.02
MP_{absol}	0.03	0.01	0.79*	0.82*	0.54*	0.50*	0.44*	0.60*
MP_{relat}	-0.15	-0.17*	-0.28*	-0.08	0.03	-0.01	-0.32*	-0.09
F.I.	0.34*	0.04	0.24*	0.11	-0.04	0.01	0.32*	0.13*

* statistically significant in $P<0.05$.

DISCUSSION-CONCLUSIONS

The results came to terms with the existing knowledge (**Table 5**); gender differences in anaerobic power were confirmed and could be stressed by higher physical activity levels. Inbar, Bar-Or and Skinner (1996) mentioned three characteristics of women that contribute to their poorer performance on the WAnT: their

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relatively inefficient skeletal configuration for certain physical demands, their higher percentage of adipose tissue and lower fat-free mass and their lower peak lactic acid level in the blood and muscle following an all-out physical effort.

There was a previous study (Weber, Chia and Inbar, 2006) in recreationally active participants, whose anthropometric characteristics (age 23.2 and 23.3 years, body mass 63.6 and 79.4 Kg, stature 1.69 and 1.78 m in females and males, respectively) were comparable to those of the present research (**Table 1**). The same study revealed higher values in absolute terms in men than in women for both PP (46 %) and MP (48 %).

Table 5. Gender differences (%) in anaerobic power from selected studies.

Participants	Peak Power	Mean Power
Recreationally active young adults[1]	46	48
Physically active young adults[2]	54	48
Physically active students[3]	60	61
Physical Education and Sport students[4]	63	60

[1]Weber *et al.*, 2006; [2]Maud and Shultz, 1989; [3]Vincent *et al.*, 2004; [4]present study.

Limitations. A shortage of the used procedures in the present study was that they didn't consider the inertial effects, which were associated with accelerating and decelerating the crank and flywheel. These alterations of velocity represented a component of the subject's power output (Reiser, Broker and Peterson, 2000). Reiser *et al.* (2000), who realized a study in male cyclists in WAnT, found the peak and mean power for the corrected methods (with inertial contribution) 20.3 % and 3.1 % greater than that of the standard method (without inertial contribution), respectively. Thus, from this point of view the standard method used in the present study was considered to underestimate the peak and mean power.

Significance. The knowledge of gender differences in students of FPESS consists a chief prerequisite for the development of effective study programs in these faculties. Studies like the present one could contribute in the scientific foundation of more precise demands and goals in the sport events and the exercise training that are taught in the separate academic classes of female and male students.

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