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Physical Activity Related to Forced Vital Capacity and Strength Performance in a Sample of Young Males and Females

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A B S T R A C T

To identify the extent of physical performance differences between active and sedentary subjects taking into account sexual dimorphism physical activity level was recorded by interview from a sample of 319 young university students of both sexes. Anthropometric variables and physical performance values were obtained. The sex factor was the main variable explaining the differences in physical performance between active and sedentary young. Also contributors to those differences were forced vital capacity (FVC), heart rate after exercise and rest heart rate, together with the explosive component of strength (vertical jump). The effect of physical activity was shown in the increment of FVC and the decrease of resting heart rate. In the overall sample, heart rate after exercise, either in active males or active females, was lowered with respect to the sedentary subjects, showing that active females experienced a greater cardiovascular benefit following adaptation to training than sedentary.

Key words*: physical activity, physical performance, males, females*

Introduction

The beneficial effects of physical activity on health are becoming progressively more apparent[1–3]. The importance of maintaining or improving strength in middle age so that functional independence is not threatened by the inevitable decline in strength in later years has been emphasized[4].

Improving health, fitness and work capacity through physical activity depends on the type, intensity, duration and frequency of exercise[5]. Marking training goals is important to improve the present state of physical fitness in the general population[6]. The young and persons of high socioeconomic status tend to be more involved in exercise and leisure activities compared to the average population. However the importance of physical activity for young people of any socioeconomic status has been emphasized since it has been positively linked to many health measures[7]. Among more than thirty different existing methods to assess physical activity, survey procedures are suitable and practical for young people in medium and large-scale studies[9]. In children, increased physical activity was found to be associated with significant decrease in percent overweight and body fat and improved aerobic fitness in follow-up studies[9]. Regular exercise, as an indicator of increasing physical activity, can improve muscular strength and endurance in children[10] and athletes[11]. However, biological maturity may influence motor fitness during adolescence[12,13], because maturation is directly related to growth and exercise performance characteristics. Several studies[14,15] support that there is a muscular component associated with FVC (Forced Vital Capacity) and overweight is associated with a reduced lung function. Multiplicative models can predict FVC from physical activity level as well as smoking habits other than height or general body size[15]. Height can be incorporated as a general allometric term in the multiplicative models[16], because some studies[15,17,18] show that FVC is proportional to height squared.

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The aim of this study is to identify the extent of physical performance differences between active and sedentary subjects taking into account sexual dimorphism. The present research is concerned with the analysis of the association of the physical activity behavior of young people in the general population with the outcomes of FVC, heart rate (in rest and after exercise) and muscle strength and uses a survey procedure to assess physical activity level in a sample of youths, with a mean age of 23 years.

Materials and Methods

Physical activity was assessed by interview in a sample of 319 university students aged 18 to 29 years (121 males and 198 females) during a survey designed by the Faculty of Biology of the Compultense University of Madrid. Mean age of the sample was 23.23 years (s= 1.99). The classification of the subjects as active or sedentary was based on the analysis of the involvement in regular moderate training exercise on the premises of the university or in other sport centers. The sport practice differed according to sex: women were preferentially engaged in swimming (22.8%), walking (19.3%), gymnastic (12,35) or cross (8.8%), while men's first choice was football and indoor football (17.6 and 11.8%, respectively), followed by cross, weight lifting and cycling (7.4% each) and by climbing (5.9%) or mountaineering (5.9%). Subjects were scheduled as active when a regular training exercise program was at least two or more days a week.

The following variables were measured:

a) anthropometry: height (cm), weight (kg), subcutaneous fat (mm) assessed by the sum of the thickness of three skinfolds: triceps, subscapular and suprailiac (each skinfold had previously been log-transformed to improve the normality of the distributions). The body mass index (BMI) was calculated as weight (kg)/height^2 (m).

b) a physical performance battery test with the following measures: FVC (mL/min) = Forced Vital Capacity (rapid and total exhalation), rest heart rate (beats/min); heart rate (beats/min) following a step test: sum of the beats during three intervals of 15 seconds (1–30, 45–69 and 75–90) after ascending and descending a bank of 45 cm height (1 minute, 30 ascensions); explosive strength: maximal vertical jump (cm) which reflects maximal leg muscle strength; power and coordination; static grip strength of the right and left hands (kg), by squeezing the dynamometer as forcefully as possible; and finally, dynamic strength: dynamometry of shoulders (kg). Indications of the International Biological Program[19] were accomplished.

Differences between sexes of the two sample subgroups (active/sedentary) were analyzed by means of a two-way analysis of variance (ANOVA) sex by activity, performing separate analysis with the anthropometry and physical performance variables one by one. The same analysis was repeated with the physical performance variables alternatively corrected for weight, height and subcutaneous fat (sum of three skinfolds) by means of multiplying each variable by 1/weight, 1/height and 1/(sum of skinfolds).

In order to reduce the number of variables describing the main characteristics of the physical performance of the whole sample, a principal component analysis (PCA) was performed, pooling sexes together. Variables included in the PCA were those with the highest contribution in the differentiation of active and sedentary in the performed ANOVA. In a subsequent step, factor scores of the three components were obtained for each subject in the sample in order to select those individuals with the best scores in physical performance. Afterwards, an overall score was computed for each subject by subtraction: a) first minus second component (C1–C2) and b) first minus third component (C1–C3). These differences also permitted the study of the relationship between physical performance and physical activity of active and sedentary subjects.

Results

Mean age regarding sex and physical activity subgroups were not significantly different either by sex ($F_{[d.f.: 1, 318]}$ = 1.527, p=0.217) or by physical activity sub-

TABLE 1
TWO-WAY ANOVA (SEX X ACTIVITY) FOR EACH VARIABLE. F VALUES AND SIGNIFICANCE LEVELS ARE SHOWN. DEGREES OF FREEDOM IN BRACKETS (D.F.) CHANGE DEPENDING ON MISSING DATA (FVC- FORCED VITAL CAPACITY, R – RIGHT HAND, L – LEFT HAND, NS – NOT SIGNIFICANT)

	Combined main effects		Sex		Physical Activity	
	F (d.f.)		F (d.f.)		F (d.f.)	
FVC	159.345 (2,314)	p<0.001	311.480 (1,317)	p<0.001	7.211 (1,317)	p<0.01
Rest heart rate	18.731 (2,289)	p<0.001	28.329 (1,292)	p<0.001	9.133 (1,292)	p<0.01
Heart rate after exercise	11.038 (2,228)	p<0.001	18.011 (1,231)	p<0.001	4.066 (1,231)	p<0.05
Explosive strength	243.037 (2,310)	p<0.001	475.350 (1,313)	p<0.001	10.724 (1,313)	p<0.01
Grip strength (r)	236.575 (2,238)	p<0.001	469.399 (1,241)	p<0.001	3.751 (1,241)	ns
Grip strength (l)	311.984 (2,239)	p<0.001	622.529 (1,242)	p<0.001	1.439 (1,242)	ns
Dynamic strength	168.898 (2,235)	p<0.001	335.364 (1,238)	p<0.001	2.432 (1,238)	ns

TABLE 2
TWO-WAY ANOVA (SEX X ACTIVITY) FOR WEIGHT (A), HEIGHT (B), FAT (C) AND VARIABLES CORRECTED FOR WEIGHT, HEIGHT AND FAT. F VALUES AND SIGNIFICANCE LEVELS ARE SHOWN. DEGREES OF FREEDOM IN BRACKETS (d.f.) CHANGE DEPENDING ON MISSING DATA

A – (SEX × ACTIVITY) for weight and variables corrected for weight						
	F (d.f.)		F (d.f.)		F (d.f.)	
Weight	137.133 (2,315)	p<0.001	272.648 (1,318)	p<0.001	1.618 (1,318)	ns
FVC/weight	13.590 (2,314)	p<0.001	24.318 (1,317)	p<0.001	2.862 (1,317)	ns
Rest heart rate/weight	106.190 (2,289)	p<0.001	203.743 (1,292)	p<0.001	8.636 (1,292)	p<0.01
Heart rate after exercise/weight	88.163 (2,228)	p<0.001	168.106 (1,231)	p<0.001	8.221 (1,231)	p<0.01
Explosive strength/weight	29.782 (2,310)	p<0.001	56.163 (1,313)	p<0.001	3.400 (1,313)	ns
Grip strength (r.h.)/weight	69.132 (2,239)	p<0.001	138.263 (1,242)	p<0.001	0.001 (1,242)	ns
Grip strength (l.h.)/weight	65.960 (2,238)	p<0.001	130.677 (1,241)	p<0.001	1.243 (1,241)	ns
Dynamic strength/weight	60.078 (2,235)	p<0.001	118.852 (1,238)	p<0.001	1.304 (1,238)	ns
B – (SEX × ACTIVITY) for height and variables corrected for height						
Height	178.441 (2,314)	p<0.001	356.128 (1,317)	p<0.001	0.754 (1,317)	ns
FVC/height	108.523 (2,313)	p<0.001	209.613 (1,316)	p<0.001	7.433 (1,316)	p<0.01
Rest heart rate/height	55.094 (2,288)	p<0.001	100.897 (1,291)	p<0.001	9.290 (1,291)	p<0.01
Heart rate after exercise/height	32.324 (2,227)	p<0.001	59.252 (1,230)	p<0.001	5.396 (1,230)	p<0.05
Explosive strength/height	172.009 (2,309)	p<0.001	333.320 (1,312)	p<0.001	10.698 (1,312)	p<0.01
Grip strength (r.h.)/height	247.687 (2,238)	p<0.001	494.545 (1,241)	p<0.001	0.829 (1,241)	ns
Grip strength (l.h.)/height	190.033 (2,237)	p<0.001	376.992 (1,240)	p<0.001	3.074 (1,240)	ns
Dynamic strength/height	132.808 (2,234)	p<0.001	263.582 (1,237)	p<0.001	2.033 (1,237)	ns
C – (SEX × ACTIVITY) for height and variables corrected for fat						
Fat	3.358 (2,242)	p<0.05	6.434 (1,245)	p<0.05	0.282 (1,245)	ns
FVC/fat	96.055 (2,244)	p<0.001	183.833 (1,241)	p<0.001	8.277 (1,241)	p<0.01
Rest heart rate./fat	1.989 (2,217)	ns	2.460 (1,220)	ns	1.518 (1,220)	ns
Heart rate after exercise/fat	2.078 (2,228)	ns	2.304 (1,231)	ns	1.853 (1,231)	ns
Explosive strength/fat	129.054 (2,238)	p<0.001	254.499 (1,241)	p<0.001	3.609 (1,241)	ns
Grip strength (r)/fat	182.726 (2,237)	p<0.001	363.052 (1,240)	p<0.001	2.400 (1,240)	ns
Grip strength (l)/fat	162.745 (2,236)	p<0.001	320.778 (1,239)	p<0.001	4.712 (1,239)	p<0.05
Dynamic strength/fat	143.236 (2,234)	p<0.001	282.579 (1,237)	p<0.001	3.892 (1,237)	p<0.05

FVC – forced vital capacity, r – right hand, l – left hand, ns – not significant

groups ($F_{[d.f.:1,\ 318]} = 0.949$, p=0.331) in a two-way analysis of variance (ANOVA), sex by activity. Combined effects of sex and physical activity together (two-way main effects) were also not significant ($F_{[d.f.:2,\ 315]} = 1.238$, p=0.291) and two-way interaction was not present.

Two-way ANOVA for each of the variables in the battery of physical performance (Table 1), showed that combined main effects sex influence and activity were highly significant (p<0.001). The principal contributions to such differences were due to sex and to a lesser degree due to physical activity. However, there is not any significant interaction of sex by activity. The FVC, heart rate after exercise and rest heart rate, together with the explosive component of the strength (vertical jump) explain the differences between active and sedentary by their significant F contributions. The other types of strength (static and dynamic) do not distinguish active and sedentary young, as a result of the non-significant F values obtained.

The two-way ANOVA showed that weight (Table 2a), height (Table 2b) and the amount of subcutaneous fat (Table 2c) yielded significant differences when sex and activity main effects are combined. These differences were due mainly to sex and not to physical activity as the F values for single factors showed. When the variables were studied with indices corrected for weight, height and fat, there were significant differences between active and sedentary subgroups, due to the following variables: rest heart rate and heart rate after exercise, both corrected by weight (Table 2a), FVC, rest heart rate, heart rate after exercise and explosive strength all corrected by height (Table 2b), grip strength of the left hand and dynamic strength (shoulders dynamometry) both corrected by fat (Table 2c).

Each of the corrected variables showed combined main effects highly significant in the two-way ANOVA, with the exception of both heart rates corrected by fat (Table 2c). On the contrary, these rates corrected by

TABLE 3
DESCRIPTIVE STATISTICS FOR THE VARIABLES WHICH DISTINGUISH ACTIVE FROM SEDENTARY SUBJECTS, SELECTED IN PCA, AND FOR THE VARIABLES OUT OF PCA

Variables		Males						Females					
		Active			Sedentary			Active			Sedentary		
In PCA	Total	X	SD	n	X	SD	n	X	SD	n	X	SD	n
FVC	318	4796.07	809.54	70	4619.00	866.61	50	3493.65	582.44	63	3251.48	568.22	135
Rest heart rate	293	69.12	9.91	67	72.76	10.14	45	74.33	8.25	61	77.54	8.84	120
Heart rate after exercise	232	81.34	14.52	59	84.80	13.45	30	87.52	13.95	46	91.58	12.77	97
Explosive strength	314	52.03	7.10	71	48.42	8.20	49	34.28	7.02	60	32.16	6.46	134
Grip strength (l)/fat	240	1.64	0.42	59	1.50	0.29	32	0.95	0.19	49	0.90	0.20	100
Dynamic strength/fat	238	3.78	1.03	59	3.37	0.81	31	1.94	0.59	48	1.86	0.67	100
out PCA													
Height	318	174.79	5.31	71	174.38	6.72	50	162.22	5.79	63	161.48	5.97	134
Weight	319	72.67	7.74	71	72.58	11.53	50	58.14	8.05	63	56.10	7.31	135
Fat	318	13.42	2.33	71	14.54	3.33	50	19.91	3.39	63	20.45	3.11	134
Grip strength (r)	243	49.19	7.64	59	48.09	7.53	32	30.61	4.24	50	29.80	4.03	102
Grip strength (l)	242	46.34	8.47	59	44.57	7.47	32	28.87	5.39	50	27.31	4.36	101
Dynamic strength	239	107.65	24.86	59	100.47	19.34	31	58.77	15.74	48	56.42	17.86	101
Grip strength (r)/fat	241	1.74	0.43	59	1.62	0.31	32	1.00	0.17	49	0.98	0.19	101

FVC – forced vital capacity, r – right hand, l – left hand, ns – not significant

weight (Table 2a) and by height (Table 2b) showed significant differences attributable to sex as well as to physical activity. There were no significant interactions of sex and activity for any of the indices and sex differences were always of higher importance than those related to physical activity to explain the variance in the sample (higher values of F by sex than by activity). The differences involved in the two-way ANOVA between sex and activity subgroups can be also confirmed by analyzing the mean values for metric and non-metric variables shown in Table 3. The variables with greater differences between activity subgroups (Tables 1 and 2) were included in the subsequent PCA. FVC, rest heart rate, heart rate after exercise, and explosive strength corrected for weight, height and fat for were not included into the PCA because the direct variables yielded significant differences between physical activity groups. On the contrary, grip strength (left hand) relative to fat and dynamic strength relative to fat, were included in PCA because direct variables did not show differences between active and sedentary groups. After this selection process, the variables considered in the PCA were finally: FVC, rest heart rate, heart rate after exercise, vertical jump, grip strength corrected for fat (left hand) and shoulder dynamometry corrected for fat.

After extracting the first three components in the PCA, with eigenvalues higher than 0.7, the adequacy of the sample was fairly high as indicated by a KMO value of 0.87. A varimax rotation improved the biological interpretation of the extracted components as shown by the comparison between rotated and non-rotated correlation matrices of variables and components.

With independence of the variable selected, in or out of PCA (Table 3), within the same activity group absolute sex differences for each variable are greater than activity differences within the same sex group, and variations between active and sedentary within each sex group are more than 12 times greater for variables included in the PCA than those excluded from PCA.

The first three principal components extracted from PCA allowed combined explanation of the 86.2% of the total variance. Table 4 shows the correlation matrix between variables and rotated components. Each variable

TABLE 4
CORRELATION OF THE FIRST THREE ROTATED COMPONENTS WITH PHYSICAL PERFORMANCE BATTERY OF TESTS. STRENGTH WAS CORRECTED BY SUBCUTANEOUS FAT. LOADINGS LOWER THAN 0.50 ARE SHOWN IN

	Components		
	C1	C2	C3
FVC	0.81	(0.09)	(–0.26)
Rest heart rate	(–0.19)	(0.16)	0.96
Heart rate after exercise	(–0.15)	0.96	(0.15)
Explosive strength	0.88	(–0.12)	(–0.05)
Grip strength (l)/fat	0.89	(–0.21)	(–0.14)
Dynamic strength/fat	0.88	(–0.21)	(–0.12)
Eigen values	3.43	1.01	0.71
%Variance explained	57.22	16.91	11.84

FVC – forced vital capacity, l – left hand

TABLE 5
TWO-WAY ANOVA (SEX X ACTIVITY) FOR THE SCORE DIFFERENCES OF THE COMPONENTS. F VALUES, DEGREES OF FREEDOM IN BRACKETS (d.f.) AND SIGNIFICANCE LEVELS ARE SHOWN

	Combined main effects		Sex		Physical activity	
C1–C2	75.620 (2,201)	p<0.001	147.392 (1,204)	p<0.001	3.865 (1,204)	P<0.05
C1–C3	105.153 (2,201)	p<0.001	203.569 (1,204)	p<0.001	6.713 (1,204)	p<0.001

C1 – first principal component, C2 – second principal component, C3 – third principal component

has different loadings, depending on the considered component. However, to improve the biological meaning of the component loadings lower than 0.50 were not considered. Therefore, the first component showed a high and positive correlation with each type of strength (explosive, static and dynamic) corrected by fat and with the FVC. Hence, this first component can be a good indicator of the physical performance in strength among subjects with FVC adapted to exercise. Subjects with high first factor score in the first component showed high scores of both strength and FVC. The second component was associated mainly with heart rate after exercise and the third was related to rest heart rate. Individuals with low scores in the last two components and high scores in the first showed good performance in strength with physiological adaptation of FVC and heart rate in rest and after exercise.

Table 5 shows a two-way ANOVA applied to component differences by pairs (C1–C2 and C1–C3). Subjects with high and positive score in the difference between the first two components (C1–C2) displayed good performance in strength and FVC as well as low scores in heart rate after exercise. The difference between the first and third component (C1–C3) can help to identify subjects with good performance in strength and FVC with low scores in rest heart rates. In the ANOVA, combined main effects of sex and activity are highly significant for both component differences. However, sex had a higher explanatory power of the heterogeneity contained in the sample with respect to the physical activity when the univariate F values for single effects (sex and activity) are contrasted. Moreover, there was no significant interaction of sex by activity.

The difference C1–C2 can be used as an overall indicator of physical performance in order to distinguish subjects by their reached percentile. Subjects with poor performance are below the 25^{th} percentile, and those with better performance are above the 75^{th} percentile. Only 4.5% of the active and 24.3% of the sedentary subjects showed a poor performance ($<P25^{th)}$ in contrast to 28.4% of the active and 7.0% of the sedentary which showed better performance ($>P75^{th}$) as can be observed in Table 6. Within the same performance group ($P<25^{th}$ or $P>25^{th}$) absolute differences between active and sedentary subjects were lower in all variables one by one with respect to the absolute differences by sex. However, absolute differences, in all of the variables, between higher performance group ($P>75^{th}$) and lower performance group ($P<25^{th}$) were greater within the same activity group than within the same sex group, proving that PCA was successful in showing the relationship of physical activity with performance and minimizing the sex effects. A reduction in resting heart rate and a slight increase in heart rate after exercise was shown in active with respect to sedentary subjects. However, differences between active and sedentary subjects with higher scores in C1–C2 ($P>75^{th)}$ were greater in strength performance corrected by fat, than in subjects with lower performance ($P<25^{th}$). Moreover, a greater relative reduction in rest heart rate was found in active subjects with higher physical performance when compared with active subjects with lower physical performance. The differences between the first and third component (C1–C3) of the PCA were more marked than the differences between the first and second component (Table 5) due to the greater reduction of the resting heart rate in subjects with better strength performance ($P>75^{th}$) and higher scores in the PCA. However, the reduction in active males (3.68 beats/min) differed slightly from active females (3.21 beats/min) as shown in Table 3.

Discussion

In general, women present lower values of absolute maximum strength compared to men[20,21]. Furthermore, these differences are higher in upper than in lower limbs[22]. The marked sexual differences found in several types of strength is a general pattern in humans as a consequence of the influences of androgens on muscle development following the onset of puberty. Body weight is an important predictor of strength for both quadriceps and biceps[23] but since muscle makes a major contribution to body mass, weight gives very little indication of a causal relationship. It has been pointed out[24] that, from dimensional arguments, the strength of a muscle would be expected to be proportional to its cross-sectional area. Body dimensions (mainly stature in girls) explain a significant proportion of variance in motor performances when using multiple regression analysis. Subcutaneous fatness has a significant effect on the variance in grip strength, endurance run and the long jump in boys[25]. With regard to relative strength by total weight or by the cross-sectional area of the muscle, gender differences decrease or do not exist in lower limbs, while in the upper they continue to be important[22]. The present study shows also higher scores of physical performance in males with respect to females even when variables were relative to weight, height and subcutaneous fat.

TABLE 6
DESCRIPTIVE STATISTICS FOR THE PHYSICAL PERFORMANCE BATTERY OF TESTS AND COMPONENTS OF THE PCA OF SUBJECTS WITH LOWER PERFORMANCE ($P<25^{TH}$) AND HIGHER PERFORMANCE ($P>75^{TH}$) WITH RESPECT TO THE DIFFERENCE C1–C2. FREQUENCIES BY SEX AND ACTIVITY WITHIN EACH SUBGROUP ARE ALSO SHOWN

	Score <P25th							
	Active		Sedentary		Males		Females	
	X	SD	X	SD	X	SD	X	SD
FVC	3712.5	690.8	3270.0	747.9	5066.7	1514.4	3305.2	564.6
Rest heart rate	74.94	11.00	76.29	9.21	77.33	13.05	75.77	9.65
Heart rate after exerc.	102.81	10.07	101.63	7.06	110.33	8.02	101.48	7.83
Explosive strength	32.94	5.93	31.89	6.86	46.00	6.56	31.35	5.55
Grip strength (r)/ fat	0.95	0.18	0.90	0.15	1.27	0.25	0.89	0.13
Grip strength (l)/ fat	0.87	0.18	0.82	0.15	1.16	0.31	0.82	0.13
Dynamic strength/ fat	1.73	0.65	1.66	0.60	2.39	0.74	1.64	0.58
C1	–0.59	0.59	–0.76	0.53	0.61	0.80	–0.79	0.42
C2	1.10	0.75	0.87	0.59	1.99	0.64	0.88	0.59
C3	–0.22	1.26	–0.01	0.98	0.03	1.53	–0.08	1.05
C1–C2	–1.69	0.53	–1.64	0.36	–1.39	0.18	–1.67	0.42
C1–C3	–0.37	1.06	–0.76	1.06	0.57	1.62	–0.71	0.99
Frequency	6 (4.5%)		45 (24.3%)		3 (2.5%)		48 (24.2%)	

	Score <P75th							
	Active		Sedentary		Males		Females	
	X	SD	X	SD	X	SD	X	SD
FVC	4741.4	996.4	4442.3	1205.0	4856.1	947.5	3233.3	563.6
Rest heart rate	68.61	9.55	73.08	10.91	68.58	9.30	78.50	11.55
Heart rate after exerc.	74.18	12.02	72.85	7.81	74.58	11.18	68.33	8.80
Explosive strength	53.63	6.09		8.94	54.09	6.31	43.67	4.32
Grip strength (r)/ fat	1.82	0.44	1.69	0.39	1.86	0.39	1.23	0.27
Grip strength (l)/ fat	1.72	0.44	1.58	0.34	1.75	0.39	1.20	0.23
Dynamic strength/ fat	4.02	1.07	3.57	1.14	4.11	0.89	2.35	1.35
C1	1.20	0.87	0.88	0.87	1.30	0.73	–0.22	0.74
C2	–0.78	0.87	–0.98	0.71	–0.73	0.81	–1.60	0.55
C3	–0.20	1.05	0.24	1.16	–0.20	1.01	0.78	1.29
C1–C2	1.98	0.79	1.86	0.47	2.03	0.73	1.39	0.32
C1–C3	1.40	1.33	0.64	1.56	1.50	1.17	–1.00	1.20
Frequency	38 (28.4%)		13 (7.0%)		45 (37.2%)		6 (3.0%)	

FVC – forced vital capacity, r – right hand, l – left hand, ns – not significant, C1 – first principal component, C2 – second principal component, C3 – third principal component

In the present study for both sexes active young were slightly taller and heavier than sedentary, but differences were not significant in weight, height and subcutaneous fat (Table 2) because the range of differences was narrow (Table 3). Active females were nearly 2kg heavier than sedentary females, the BMI being also similar (22.05 and 21.52 in active and sedentary females and 23.82 and 23.79 in active and sedentary males). The effect of physical exercise on weight can be taken only partially into account, because the loss of fat mass can be compensated for by the increase of lean mass.

In sedentary adults, the main determinant of energy expenditure is fat-free mass[26]. Therefore, differences in muscular strength would be expected between active and sedentary young. In fact, differences in explosive strength performance distinguish active and sedentary young (Table 1), even corrected by height (Table 2b), as well as by static and dynamic strength per unit of subcutaneous fat (Table 2c) due to the slight reduction of subcutaneous fat in active subjects and the parallel increase in strength with training (Table 3). The lower amount of subcutaneous fat and higher strength performance of the active young suggests a possible increase in fat-free-mass due to physical activity. It was found[27] that when athletes and sedentary subjects are matched for BMI, age and sex, athletes showed a strong reduction in total fat mass. The effect of activity, fundamentally aerobic, on fat is well established; for instance, physical activity in non extreme obese causes a reduction of fat weight by the reduction of the volume of adipocites[28]. Moreover, studies on forced resting due to surgical interventions showed that extreme sedentary periods influence body composition changes, such as the loss of muscular mass and the rise of fat mass[6] together with other physiological alterations of the excretion of minerals[29]. So, the effects of moderate sedentary practice, as the case of sedentary young in the present sample, should be expected to affect body composition in the same way, but to a lesser extent.

Males of the present study showed sex differences of subcutaneous fat and strength between active and sedentary subjects (Table 3) than did females. This can be attributed to androgenic hormonal background. Active males become leaner and stronger than sedentary males, displaying the effects of moderate training in a more marked way than do females. However, females had greater differences than males in height and weight between the two subgroups of activity. This could be attributed to a more marked effect of physical activity on body composition in females (loss of fat with an increase of fat-free-mass), and to the possible existence of social factors that encourage more muscular girls to practice more exercise.

The effect of moderate training by aerobic exercise is shown in the present study, i.e, the increment of FVC and the decrease of resting heart rate as described by earlier studies[6,30]. The decrease of resting heart rate in trained subjects is probably due to a diminution of the activity of the sympathetic system and an increase in the activity of the parasympathetic system[30]. A sedentary state increases rest heart rate in young people after twenty days of voluntary bed resting[31]. In the present study, the decrease in heart rate is greater with higher physical performance as shown in Table 6 and is not reduced after exercise in active subjects within extreme scores in the PCA. However, in the overall sample, heart rate after exercise, either in active males or active females, was lowered by 3.46 beats/min. in males and by 4.06 beats/min. in females with respect to the sedentary subjects (Table 3). These results show that active females experienced a greater cardiovascular benefit following adaptation to training. The adaptation is a general trend found when heart rate increases during exercise followed by a relative decrease with time in trained subjects[6].

Although physical activity improves physical performance, some non trained individuals perform better than expected and some trained ones (low training levels) perform worse than expected. Therefore, the research on the effects of physical activity regarding performance should be widened with the consideration of limiting physical factors such as the study of body constitution or the study of the influence of genetic determinants on performance.

Conclusion

From the present study it is concluded that regarding both sexes, although active young were slightly taller and heavier than sedentary, there were no significant differences in weight, height and subcutaneous fat between them. Differences in explosive strength performance distinguish active and sedentary young, even corrected by height as well as by static and dynamic strength per unit of subcutaneous fat, due to the slight reduction of subcutaneous fat in active subjects and the parallel increase in strength with training. The lower amount of subcutaneous fat and higher strength performance of the active young suggest a possible increase in fat-free-mass due to physical activity. Active males become leaner and stronger than sedentary males, displaying the effects of moderate training in a more marked way than do females. However, females had greater differences than males in height and weight between the two subgroups of activity, perhaps due to a larger effect of physical activity on body composition, and to social factors encouraging more muscular girls to practice exercise. The decrease in heart rate is greater with higher physical performance. In the overall sample, heart rate after exercise, either in active males or active females, was lowered with respect to the sedentary subjects, showing that active females experienced a greater cardiovascular benefit following adaptation to training than sedentary.

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FIZIČKE AKTIVNOSTI POVEZANE SA FORSIRANIM VITALNIM KAPACITETIMA NA UZORKU MLADIH ŽENA I MUŠKARACA

S A Ž E T A K

Za identifikaciju razlike u fizičkim aktivnostima između aktivnih i sjedilačkih subjekata korišteni su intervjui na uzorku od 319 ispitanika, sveučilišnih studenata oba spola. Proučavane su antropološke varijable i fizičke aktivnosti. Spol je bio glavni faktor prema kojem su se razlikovale fizičke aktivnosti. Razlike su se očitovale u forsiranom vitalnom kapacitetom (FVC), frekvenciji rada srca nakon aktivnosti i nakon mirovanja te komponenta eksplozivnosti (nakon vertikalnog skoka). Efekt fizičkih aktivnosti pokazan je porastom FVC-a i smanjenjem frekvencije rada srca. U ukupnom uzorku je pokazano kako se frekvencija rada srca znatno više smanjuje kod muškaraca i žena koji su inače aktivni nego kod sjedilačkih subjekata.