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Relationship between the level of physical activity and markers of cardiovascular health in Valencian adolescents (Spain)

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ABSTRACT

Introduction. A sedentary lifestyle is not only a major cardiovascular risk factor from an early age, it also contributes to the development of other cardiovascular risk factors. The objective of this study was to determine the level of physical activity and relate it to cardiovascular risk markers in Valencian adolescents according to their anthropometric characteristics and gender.

Population and Methods. The following variables were assessed in a randomized sample of 583 Valencian adolescents (Spain) aged 12-18 years: level of physical activity, using a validated questionnaire; weight, height and waist circumference; aerobic capacity, using the multi-stage fitness test (Course-Navette test); and muscle strength, using a manual dynamometry.

Results. In total, 57.60% of male adolescents and 14% of female adolescents complied with the recommendations for physical activity. The prevalence of excessive weight, waist circumference with risk, and aerobic capacity with risk was 24.90%, 29.30% and 20.60%, respectively among boys, and 15.10%, 23.20% and 24.70% among girls ($p < 0.005$).

Conclusions. A higher level of physical activity in adolescents is related to a lower body mass index, a smaller waist circumference and less excessive weight in male adolescents, and to a higher aerobic capacity and a lower cardiovascular risk in both male and female adolescents. Aerobic capacity and waist circumference with risk are significantly higher among subjects with excessive weight.

Key words: *physical activity, adolescents, cardiovascular health, gender.*

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INTRODUCTION

Sedentariness is related to cardiovascular diseases.[1,2]

A fast reduction in the levels of physical activity usually takes place during adolescence.[3] Spain is one of the countries where this situation has been described,[4] with a growing trend;[5] probably as a result of this, the rates of obesity and type 2 diabetes are now increasing in this population.[6] Furthermore, doing physical activity during adolescence helps to adopt a healthy lifestyle during adulthood.[7]

One of the public health problems among children and adolescents today is the growing trend in overweight.[8,9] Spain is also affected by this epidemics and is one of the countries with the highest rates in Europe,[10] with an increased distribution of central fat mass.[11] Such distribution of fat is more related to cardiovascular diseases than generalized obesity.[12]

It has been demonstrated that sedentary lifestyle is one of the most significant cardiovascular risk factors, and is considered as a predictor of all-cause morbidity and mortality.[13] The main markers of cardiovascular risk are limited aerobic capacity[13] and reduced muscle strength.[14] Recent data indicate that approximately 20% of Spanish adolescents will have a higher cardiovascular risk (as per their aerobic capacity) during adulthood.[15]

Studies conducted in children and adolescents showed that with a higher level of physical activity, there was a lower prevalence of overweight, obesity and central obesity. However, other studies[6] have not identified such associations. These controversial results may be a consequence of the complexity entailed by measuring physical activity[16] and require to be investigated in depth.

The objective of this study was to determine the level of physical activity and relate it to cardiovascular risk markers in Valencian adolescents according to their anthropometric characteristics and gender.

POPULATION AND METHODS

This was an observational, cross-sectional study with the

administration of surveys in a systematic, voluntary and confidential manner, the collection of anthropometric measurements, and the performance of tests to determine cardiovascular risk.

In 2009, there were 50,028 adolescents aged 12-18 years old (25,692 males and 24,336 females) living in Valencia. Three schools were randomly selected, a copy of the study protocol was delivered for their approval and they accepted to participate. A signed consent was also requested to participating adolescents and their father/mother or legal guardian.

Professionals in charge of the Physical Education Departments of the different schools helped with data collection. A representative sample of adolescents (aged 12-18 years old) was selected by means of a systematic sampling stratified by gender, with a 0.05 error and a 95% confidence interval for an estimated prevalence of compliance with physical activity recommendations[17] by gender of 50% for males and 30% for females, considering a 20% difference between groups. The sample size was 280 pairs of boys and girls (560 subjects). The inclusion criterion was having completed the initial assessment questionnaire at the beginning of their course. Exclusion criteria were: clinical diagnosis of a chronic disease with a contraindication to physical activity, having an acute disease or using any medication at the time of the tests.

Height was measured with the subject in standing position and his/her head adjusted to the Frankfurt plane (horizontal plane from the nose to the tragus). The body mass index was also calculated (BMI= kg/m^2).

As markers of cardiovascular risk, this study used the overweight and obesity criteria proposed by Cole, et al. in 2000.[17] These criteria suggest a cut-off point of 25-30 kg/m^2 at 18 years old. For central obesity or waist circumference with risk, the cut-off values proposed in the Bogalusa Heart Study were used.[18]

The physical activity level (PAL) was assessed using an anonymous, self-administered questionnaire especially developed for this study, which underwent a process of validation and reliability verification. Surveys were administered in the three schools using a standard protocol. Information was collected on the frequency and duration of physical activity done usually during the week, both during school hours and after school, including the trip to and from school (walking, cycling). The total time of, at least, moderately intense physical activity (>3 metabolic equivalents [MET])[19] accumulated by the subject along the day was calculated. A physical activity level index was created using frequency and duration as variables, and four levels were established (a minimum of 60 minutes a day) *(Table 1)*.

Following international recommendations regarding physical activity during adolescence, it is estimated that adolescents should do at least 60 minutes of moderate to vigorous physical activity a day, on all or most days of the week. Based on this criterion, adolescents were considered to meet the recommendations if they did physical activity 5 or more days a week for at least 60 minutes a day, and they were considered sedentary if they did physical activity less than once a week.

For the assessment of physical fitness, two tests included in the Eurofit Physical Fitness Test Battery were used, which are validated and standardized by the Council of Europe. Aerobic capacity was assessed using the multi-stage fitness test or 20 meter shuttle run test. This is a cardiorespiratory endurance test that measures maximal aerobic power and, indirectly, maximum oxygen uptake (VO_2max) and is the main indicator of a subject's physical fitness; maximal oxygen uptake (VO_2max) is the physiological variable that best defines fitness in relation to cardiovascular capacity. VO_2max was estimated directly using maximal or submaximal stress tests. The maximum oxygen uptake is the maximum amount of oxygen that cells can consume. It is expressed as liters per minute (L/min) or milliliters per kilogram per minute (mL/kg/min). A higher value indicates that the body has a higher capacity to produce energy via the aerobic metabolism, a reduced need to use lactic anaerobic metabolism, and a higher capacity to remove lactic acid (if produced at all), and such value is therefore considered

TABLE 1. *Classification of levels of physical activity*

Group	Moderate or vigorous physical activity	Classification
1	Less than 1 day a week	Sedentary
2	1 day a week	Moderately active
3	2-4 days a week	Moderately active
4	5 or more days a week	Meets the recommendations

an indirect maximum incremental field test. The test reliability and validity to predict VO_2max in children and adolescents have been sufficiently demonstrated (r= 0.70; for children and adolescents aged 8-19 years old).[20] The maximum velocity at which the subject moved before stopping was taken and used in a formula to estimate VO_2max. In order to calculate the VO_2max based on the multi-stage fitness test result, the equations proposed by Leger, et al. were used:20

$$VO_2max = 31.025 + 3238\,V - 3248\,A + 0.1536\,VA\ (mL/kg/min)$$

Where V (km/h) is the final velocity reached during the test:

V= 8 + 0.5 x last completed stage.

A represents age in years.

Adolescents were classified as having aerobic capacity with risk according to the cut-off values determined by the Cooper Institute.[21] The threshold of cardiovascular health has been set at a VO_2max of 42 mL/kg/min for all male adolescents, at 35 mL/kg/min for girls as of 14 years old, and at 38 mL/kg/min for younger girls; when values are lower than these, adolescents are considered to pose a risk for cardiovascular health.

Muscle strength was assessed using a manual dynamometry to measure maximum grip strength in both hands with a hand-held Collin dynamometer (range: 0-70, 1 kg precision) making two different attempts with each hand in a standardized position, standing and with the arms parallel to the body and not touching it.

Statistical Analysis

A descriptive, univariate analysis of collected outcome measures was performed using absolute and relative frequencies (percentages) for qualitative outcome measures, and mean, median, maximum, minimum and standard deviation for quantitative outcome measures, stratified by gender. A bivariate analysis was then performed to find the association between the level of physical activity and the markers of cardiovascular health using the Pearson's χ^2 test. Mean values were compared using an ANOVA test and the correlation analysis technique (Pearson's test). The risk of overweight on the markers of cardiovascular health: waist circumference and aerobic capacity, was also calculated, stratified by gender and using a binary logistic regression. In all cases, the level of significance was established at 0.05. A non-conditional logistic regression model was applied to determine the relationship between the levels of physical activity and the markers of cardiovascular health. The SPSS software for Windows, version 19.0, was used.

RESULTS

Out of the 625 subjects who met the study inclusion criteria and were invited to participate in the study, 583 adolescents (280 boys and 303 girls) agreed to take part, resulting in a 93.28% participation rate.

Male adolescents have a higher compliance with PAL recommendations, altogether, when compared to female adolescents (p= 0.001). When stratified (<1, 1 and 2-4 times a week), sedentary lifestyle (physical activity less than once a week) is remarkably higher among girls (26.90%) than among boys (9.70%) *(Table 2)*.

Boys showed an association between the level of physical activity and the BMI (p= 0.003), waist circumference (p= 0.001), muscle strength

TABLE 2. *Number and percentage of adolescents who meet the recommendations on physical activity and level of physical activity based on gender*

	Compliance with recommendations*									
	No								**Yes**	
	Level of physical activity (days/week)**									
Gender	< 1		1		2-4		Total NO		≥ 5	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Boys (*n*= 269)	26	9.70	20	7.40	68	25.30	114	42.40	155	57.60
Girls (*n*= 279)	75	26.90	73	26.20	92	33	240	86	39	14
Total (*n* = 548)	101	18.40	93	17	160	29.20	354	64.60	194	35.40

* To do at least 60 minutes of moderate to vigorous physical activity on 5 or more days of the week.

** At least 60 minutes a day.

(p= 0.001), and aerobic capacity (p = 0.001) *(Table 3)*. Both the BMI and waist circumference are lower with an increased level of physical activity, showing a negative correlation (-0.227 and -0.201, respectively) with doing physical activity. Such correlation was not found among girls, although those who meet the recommendations have a lower BMI.

The higher level of physical activity, the more the aerobic capacity among both male and female adolescents.

Muscle strength increases with a higher level of physical activity among girls. The correlation between the PAL and aerobic capacity is positive (0.251 in boys and 0.250 in girls).

The rate of excessive weight (overweight and obesity) is higher among males *(Table 4)* and becomes lower as physical activity increases; this is not the case among females. The prevalence of boys with a waist circumference indicative of vascular risk is higher than in female adolescents, with no differences observed in relation to the PAL.

Aerobic capacity with cardiovascular risk is more common among female than male adolescents; and such rate is lower as the level of physical activity increases in both.

A logistic regression model was done to assess the effect of obesity on the studied markers of cardiovascular health and it showed that aerobic capacity with risk, waist circumference with risk, and excessive weight are higher in both male and female adolescents, compared to the values obtained in adolescents who met the recommendations.

Adolescents with excessive weight have a significantly higher value of waist circumference with risk (p= 0.001, both males and females) as well as of aerobic capacity with risk (p= 0.001 in males, and p= 0.034 in females).

The type of obesity observed in the studied adolescents was central distribution fat mass; excessive weight increases the probability of having a larger waist circumference (OR= 13.76) and reduces aerobic capacity (OR= 3.92) among both boys and girls *(Table 5)*.

DISCUSSION

The study demonstrated that 64.6% of studied Valencian adolescents do not meet the recommendations on physical activity, while 29.2% do physical activity 2-4 times a week and are considered to be moderately active subjects.[22,23] These results are consistent with the

TABLE 3. *Mean and standard deviation values of body mass index, waist circumference, muscle strength and aerobic capacity of adolescents based on their level of physical activity and gender*

Level of physical activity (days/week)	Gender	Body mass index (kg/m²)		Waist circumference (cm)		Muscle strength (kg)		Aerobic capacity (mL/kg/min)	
		Mean	SD*	Mean	SD*	Mean	SD*	Mean	SD*
< 1	Boys	23.03	3.66	77.52	10.67	70.77	23.63	45.67	6.81
	Girls	20.59	2.47	65.57	6.98	31.52	14.15	39.03	6.61
	Total	21.06	3.03	68.55	9.54	42.04	24.43	40.78	7.25
1	Boys	24.37	3.37	78.35	6.70	65.05	16.34	46.56	10.43
	Girls	20.45	3.05	67.30	6.37	31.45	15.31	41.89	7.51
	Total	21.22	3.47	69.49	7.77	38.68	20.76	42.81	8.30
2-4	Boys	22.19	3.71	74.66	8.65	63.88	23.98	48.35	7.85
	Girls	21.54	3.48	68.68	8.39	33.63	13.92	41.85	7.41
	Total	21.82	3.58	71.27	8.98	46.34	24	44.54	8.23
Total number who DO NOT meet the recommendations	Boys	22.75	3.70	75.90	8.92	65.69	22.72	47.42	8.10
	Girls	20.84	3.10	67.29	7.45	32.31	14.41	41	7.30
	Total	21.45	3.41	71.49	8.90	43.09	23.46	43.01	8.11
> 5	Boys	21.20	3.36	73.01	7.62	64.40	25.14	51.33	7.58
	Girls	19.78	2.38	65.28	4.57	33.82	12.67	45.48	6.25
	Total	20.92	3.23	70.03	7.75	58.22	26.21	50.14	7.68
Total	Boys	21.85	3.59	74.26	8.20	65.14	24.36	49.65	7.96
	Girls	20.71	2.98	67.05	7.09	32.46	13.84	41.29	7.25
	Total	21.26	3.34	70.56	8.45	48.26	25.54	45.30	8.66

* Standard deviation.

findings described in the adolescent population of Europe and outside the European Union,[3,4] except for Scandinavian countries.[24]

Only 14% of girls comply with the recommendations; their most common level of physical activity is on 2-4 days of the week, as observed in other studies.[25]

These results among female adolescents are alarming, especially taking into consideration that the level of physical activity reduces with age.[26] It has been proposed that sound healthy habits, including physical activity, should be developed from childhood,[27] and such proposal should be especially targeted at female children and adolescents. It is necessary to create more opportunities for adolescents to do physical activity and turn it into an appreciated asset; to make families, educators, healthcare professionals, health authorities and any other social agent aware of the fact that physical activity not only improves fitness and well-being, but also individual's present and future health status.[25] Our study confirms the situation described in Spain and outside our country.[1,28]

This study found that male adolescents are more prone to having excessive weight, a higher BMI and waist circumference than female adolescents. Compared to another study, regardless the classification criterion used, results indicate that, in general, males are more affected by overweight and obesity than females.[26] Further research is required on the differences in eating habits by gender, since women seem to be much more concerned on limiting food intake as a weight control strategy.

Boys showed to have higher levels of physical activity if they had lower BMI, waist circumference and excessive weight values, but this was not the case with girls. This shows a partial agreement with several studies that found an association between a higher level of physical activity and lower percentages of excessive weight[15] and central fat distribution[13] in children and adolescents, or with lower BMI values.[27]

No significant differences were observed between waist circumference with risk and the different levels of physical activity; but also in agreement with other studies[29] an association with

TABLE 4. *Number and percentage of adolescents with excessive weight, waist circumference with risk, and aerobic capacity with risk based on the level of physical activity and gender*

Level of physical activity (days/week)	Gender	Excessive weight						Waist circumference with risk[a]						Aerobic capacity with risk[b]					
		No		Yes		*Odds ratio*	CIc 95%[c]	No		Yes		*Odds ratio*	CIc 95%[c]	No		Yes		*Odds ratio*	CIc 95%[c]
		n	%	*n*	%			*n*	%	*n*	%			*n*	%	*n*	%		
> 5	Boys	124	81	29	19	1	-	114	75	38	25	1	-	135	88.2	18	11.8	1	-
	Girls	35	94.6	2	5.4	1	-	33	89.2	4	10.8	1	-	38	97.4	1	2.6	1	-
	Total	159	83.7	31	16.3	1	-	147	77.8	42	22.2	1	-	173	90.1	19	9.9	1	-
Total number																			
who DO NOT	Boys	69	66.3	35	33.7	2.17	1.22-3.85	67	64.4	37	35.6	1.66	0.96-2.85	69	66.3	35	33.7	3.80	2.01-7.20
meet recom-	Girls	185	83.3	37	16.7	3.50	0.81-15.19	166	74.8	56	25.2	2.78	0.94-8.20	163	71.5	65	28.5	15.15	2.04-112.68
mendations	Total	254	77.9	72	22.1	1.45	0.91-2.32	233	71.5	93	28.5	1.40	0.92-2.12	232	69.9	100	30.1	3.92	2.31-6.66
2-4	Boys	47	73.4	17	26.6	1.55	0.78-3.07	44	68.8	20	31.2	1.36	0.72-2.60	48	77.4	14	22.6	2.19	1.01-4.73
	Girls	67	79.8	17	20.2	4.44	0.97-20.3	58	69.1	26	30.9	3.70	1.19-11.52	66	75	22	25.0	12.67	31.64-97.75
	Total	114	77	34	23	1.53	0.89-2.63	102	68.9	46	31.1	1.58	0.97-2.57	114	76.0	36	24.0	2.88	1.57-5.26
1	Boys	8	47.1	9	52.9	4.81	1.71-13.54	9	52.9	8	47.1	2.67	0.96-7.40	7	41.2	10	58.8	10.71	3.62-31.67
	Girls	58	84.1	11	15.9	3.32	0.69-15.86	51	73.9	18	26.1	2.91	0.91-9.37	54	77.1	16	22.9	11.26	1.43-88.56
	Total	66	76.7	20	23.3	1.55	0.83-2.92	60	69.8	26	30.2	1.52	0.85-2.62	61	70.1	26	29.9	3.88	2.01-7.51
< 1	Boys	14	60.9	9	39.1	2.75	1.08-6.67	14	60.9	9	39.1	1.93	0.77-4.81	14	56	11	44	5.89	2.32-14.94
	Girls	60	87	9	13	2.63	0.54-12.85	57	82.6	12	17.4	1.74	0.52-5.83	43	61.4	27	38.6	23.86	3.09-184.07
	Total	74	80.4	18	19.6	1.25	0.66-2.37	71	77.2	21	22.8	1.04	0.57-1.88	57	60.0	38	40	6.07	3.24-11.36
Total	Boys	193	75.1	64	24.9	-	-	181	70.7	75	29.3	-	-	204	79.4	53	20.6	-	-
	Girls	220	84.9	39	15.1	-	-	199	76.8	60	23.2	-	-	201	75.3	66	24.7	-	-
	Total	413	80	103	20	-	-	380	73.8	135	26.2	-	-	405	77.3	119	22.7	-	-

[a] As per Katzmarzyk, et al., 200418; [b] As per the Cooper Institute, 200421; [c] 95% confidence interval estimated by logistic regression.

excessive weight was observed in both genders. Having an increased central fat mass distribution has alarming implications on an individual's future health.[29]

Knowing the level of physical fitness of a person during adolescence is important to establish his/her future cardiovascular risk.[12] Both aerobic capacity and muscle strength are higher among the male adolescents of our study; such differences were higher than those expected based on biological differences; this was especially the case with the muscle strength test among girls, who had very low results. Also consistent with other studies,[12] these results may be interpreted as predictors of loss of health once such adolescents become adults. Muscle strength has proven to be a strong predictor of mortality and life expectancy[30] and, most importantly, of independent life expectancy.[12]

Some studies have identified a progressive worsening of adolescents' aerobic capacity when compared to previous decades,[31] which has been attributed to the increasing sedentary lifestyle in industrialized societies.[31]

We found that 20.3% of boys and 26% of girls have an aerobic capacity considered to pose risk,[18,28] i.e., they have a higher chance of developing a cardiovascular disease in the future.

Our study found more adolescents with a reduced aerobic capacity than previous studies,[12] but better than the study by Pate, et al. (2006)[32] in US adolescents.

One of our study's limitations is the representativity of the sample; so based on the results, it would be interesting to do larger studies to confirm our results. However, thoroughness and the effort in data collection coordination are some of the strengths of this study.

CONCLUSIONS

This study demonstrates that the level of physical activity in adolescents is reversely correlated with aerobic capacity with high cardiovascular risk; therefore, this population seems to be an ideal target for the promotion of health through physical activity.■

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TABLE 5. *Number and percentage of adolescents with waist circumference with risk and aerobic capacity with risk based on gender and excessive weight*

Gender	Excessive weight	Waist circumference with risk[a]						Aerobic capacity with risk[b]					
		No		Sí		*Odds ratio*	CIc 95%[c]	No		Sí		*Odds ratio*	CIc 95%[c]
		n	%	n	%			n	%	n	%		
Boys	No	170	85	30	15	1	-	173	88.3	23	11.7	1	-
	Yes	17	25.4	50	74.6	16.67	8.50-32.68	28	47.5	31	52.5	8.33	4.26-16-29
Girls	No	202	84.2	38	15.8	1	-	171	74.7	58	25.3	1	-
	Yes	14	33.3	28	66.7	10.63	5.13-22.04	24	58.5	17	41.5	2.09	1.05-4.16
Total	No	372	92.3	68	15.4	1	-	344	80.9	81	19.1	1	-
	Yes	31	28.4	78	71.6	13.76	8.43-22.47	52	52	48	48	3.92	2.47-6.22

[a] As per Katzmarzyk, et al., 200418; [b] As per the Cooper Institute, 200421; [c] 95% confidence interval estimated by logistic regression.

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