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Adolescents with high intellectual ability: differences in body composition and physical activity by sex

Adolescentes con alta capacidad intelectual: diferencias en su composición corporal y actividad física por sexo

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ABSTRACT

Objectives: Physical activity (PA) has been shown to have multiple health and wellness benefits, but there is no such information for adolescents with high intellectual ability (HIA). Thus, the aim of this study is to assess body composition and PA in HIA Chilean adolescents.

Methods: Weight and body composition were measured by bioelectrical impedance in 73 adolescents (39 female) aged 14-18 years from the Valparaíso region of Chile. HIA was assessed via Raven's Progressive Matrices (> 75th percentile) and PA, via questionnaire. Obesity was defined as a body fat percentage (BF%) ≥ 25 (for boys) or ≥ 30 BF% (for girls).

Results: Obesity prevalence was 43.59% in females and 8.82% in males. A total of 69% of adolescents performed more than two hours of weekly exercise, with the amount being greater in males. BF% and fat mass index were significantly different ($p < 0.05$) in adolescents who engaged in fewer than two hours of weekly exercise. On the contrary,

subjects who performed more than two hours of weekly exercise exhibited higher mass muscle percentages (p < 0.01). After controlling for socioeconomic status and PA, the obesity odds ratio (OR = 7.6; 95% CI: 1.9-30.9) was significantly higher in females (p < 0.01).

Conclusions: Adolescents with HIA reported elevated PA. However, obesity was more prevalent in females, who also reported less weekly PA than males.

Key words: Physical activity. Gifted and talented. School-aged children. Chile.

RESUMEN

Objetivos: la actividad física (AP) ha demostrado múltiples beneficios en salud, pero no hay información en adolescentes con altas capacidades intelectuales (ACI). El objetivo de este estudio es evaluar la composición corporal y AF en adolescentes chilenos con ACI.

Métodos: la composición corporal fue evaluada por bioimpedancia en 73 adolescentes (39 mujeres) de 14 a 18 años de la Región de Valparaíso, Chile. La ACI se evaluó a través del test de matrices progresivas de Raven y la AF, a través de un cuestionario. La obesidad se definió mediante el porcentaje de grasa corporal (%GC) ≥ 25 (hombres) y ≥ 30% (mujeres).

Resultados: la prevalencia de obesidad fue del 43,59% en mujeres y del 8,82% en hombres. Un 69% de los adolescentes realizan más de dos horas de ejercicio semanal, siendo mayor en hombres. El %GC y el índice de masa grasa fueron significativamente diferentes (p < 0,05) en adolescentes que realizan menos dos horas de ejercicio semanal. Por el contrario, los sujetos que realizan más de dos horas de ejercicio semanal presentaron mayores porcentajes de masa muscular (p < 0,01). Después de controlar por nivel socioeconómico y AF, el *odds ratio* para obesidad (OR = 7,6; IC del 95%: 1,9-30,9) fue significativamente asociado a las mujeres (p < 0,01).

Conclusiones: los adolescentes con ACI reportaron alta AF semanal. Sin embargo, la obesidad fue más prevalente en mujeres, que también informaron menor AF semanal.

Palabras clave: Actividad física. Dotado y talentoso. Niños en edad escolar. Chile.

INTRODUCTION

Children and adolescents who systematically engage in moderate or high-intensity physical activity (PA) reap multiple health and wellness benefits (1-3). Additionally, a positive

influence on academic performance is observed because PA and aerobic fitness improve attention, favoring interactions between the learning environment and cognitive development (4-6). Moreover, cardiorespiratory exercise favors neuronal plasticity, neurocognitive function and cerebral activity (7). On the contrary, sedentary behavior is reported to contribute to energy imbalance, which can lead to health alterations, such as obesity or non-communicable chronic diseases (NCDs) (8,9).

According to data from the World Health Organization (WHO), in 2010, approximately 81% of students between 11 and 17 years old were sedentary (10). The trend in Chile is similar, and the prevalence of sedentary behavior in those aged 15 to 24 years is up to 75.9%. This percentage dramatically increases to 90.5% by adulthood according to the National Health Survey (11).

Adolescents of low socioeconomic status (SES) exhibit a high prevalence of sedentary behavior (12,13). In addition, a high prevalence of obesity has been reported among children and adolescents of low SES (14,15). Yet, school-aged children (approximately 5-17 years old) spend seven or more hours in school; because of reforms promoted by the Chilean Ministry of Education to improve the quality of learning, this time is spent mainly seated. However, the weekly time devoted to PA, which is approximately 90 minutes per week, has not changed, contributing to caloric retention (16). It is also observed that Chilean students who report high levels of PA perform better on standardized tests (17,18) and obtain health and wellness benefits. There is a group of students who regularly attend school and special academic programs due to their high intellectual ability (HIA). Reports show that almost 10% of the population is of HIA (19) and are characterized by greater intellectual skill and faster learning than their peers. They have also perfectionist, critical and creative tendencies (19-21), resulting in interrelations between opportunity, personality, psychosocial factors, individual effort and neurobiological base (21).

A relation between PA and HIA has not been reported yet; however, there are studies of adolescent students, although without a focus on HIA, supporting the positive influence of PA on academic performance. Thus, it is necessary to determine the PA of these students to identify a possible relation between HIA and PA. Therefore, our aim is to evaluate the body composition and PA of adolescents of HIA who attend an academic talent program.

METHODS

The target population was all students in grades 9 to 12 from different schools who regularly attended an academic talent program named "*Buenos Estudiantes con Talento Académico (Good Students with Academic Talent) de la Pontificia Universidad Católica de Valparaíso*" (BETA PUCV) (22) in the region of Valparaíso, Chile. Sampling was conducted from April to October 2014. To represent the student population of the BETA PUCV program (n = 169), obesity (as measured by body mass index [BMI]) was selected as the variable with the greatest variance for this age group (8.5% of adolescents from the region of Valparaíso have BMI values in the obese range (23). Sampling was performed with 95% reliability and a 5% sample error. The minimum sample size needed was n = 71. Seventy-nine students agreed to participate in the study (39 males). The final sample consisted of 73 students aged 14 to 18 years (46.48% males; 16 ± 1.19 years) who attend public schools, provided complete personal and SES data, completed the entire PA questionnaire and provided complete anthropometric measurements (bioelectric impedance could not be conducted in six students).

Anthropometric measurements

Weight was evaluated using a TANITA BC420SMA precision bascule (100 g sensitivity; Tanita, Tokyo, Japan) and height, using the SECA 217 stadiometer (0.1 cm precision; Seca, Hamburg, Germany). BMI (weight [kg]/height [m^2]) was classified as eutrophic or overweight (including obese) based on the references and z-scores for sex and age (24). Body fat percentage (BF%), muscle mass percentage (MM%) and fat mass index (FMI: fat mass [kg]/height [m^2]) were assessed via tetrapolar bioelectric impedance (TANITA BC420SMA). Measurements were conducted at room temperature under the following conditions: subjects did not wear metallic objects, did not drink alcohol at least 48 hours before the measurement, did not engage in intense exercise at least 12 hours before the measurement, did not eat or drink (especially caffeine) at least four hours before the measurement, had urinated 30 minutes before the measurement, and did not take diuretics before the measurement.

In this study, obesity was defined by BF%; subjects with body fat ≥ 25% in males and ≥ 30% in females were considered to be obese based on their relations with NCDs (25).

Physical activity habits

Weekly PA was evaluated through a questionnaire designed for Chilean students (16) and validated via accelerometer measurements (26). A questionnaire was completed by each adolescent. The PA questionnaire comprises five items: a) daily hours spent lying down; b) minimum time spent on activities (classes, TV, homework or studying, and video games); c) time spent walking; d) time spent on recreation; and e) scheduled PA time (inside and outside of school). The questionnaire was administered under the supervision of a researcher (JE) to all students at the same time. The questionnaire scores range from 0 to 10 points and are classified by levels: low (0-3 points), regular (4-6 points) or high (7-10 points) (27).

The number of scheduled hours devoted to PA was obtained from item 5 in the questionnaire. Then, the amount of scheduled PA was classified as ≤ 2 hours or > 2 hours.

High intellectual ability

HIA was evaluated using the Raven's progressive matrices general scale (28) by the BETA PUCV program psychologist (PC). This test contains 60 problems divided into five series (12 elements each) in order of increasing difficulty. The cohort distribution is determined by the talent program following the standards and percentiles determined by the Chilean Ministry of Education (MINEDUC) (29). To join the BETA PUCV program, students must test above the 75th percentile, that is, at level II (intellectually above average) or above with respect to the student cohort.

Socioeconomic status

SES was determined through an ESOMAR questionnaire, which evaluates the occupation and educational level of the breadwinner (30). This questionnaire classified the sample into six socioeconomic groups: very high SES (A), high (B), medium-high (CA), medium (CB), medium-low (D) and low (E). In our analysis, we merged these six categories into four groups: 1) A+B; 2) CA; 3) CB; 4) D+E.

Pubertal development

Pubertal development was evaluated according to Tanner stages (31). Photographs of the five Tanner stages were shown to each adolescent, who was then asked to select the photo that best described their stage of development.

Statistical analysis

A descriptive analysis was performed using frequencies, means, standard deviations and percentages. Data normality was evaluated separately for each variable using Shapiro-Wilk normality tests. Significant differences in PA by sex were evaluated based on a Mann-Whitney U test (non-parametric) and Student's t-test. For categorical variables, Chi-squared and Fisher's exact tests were used. Logistic regression was used to relate obesity (BF%; independent variable) to sex, adjusting for PA and SES. The data were processed using STATA 12.0 for Windows, and $p < 0.05$ was considered as significant.

Ethical aspects

The processes of anthropometric measurement, bioelectric impedance analysis and questionnaire completion were orally explained to and authorized by the adolescents and their parents. Informed consent forms were signed by the adolescents and their parents. This study was approved by the Ethics Committee of the Pontificia Universidad Católica de Valparaíso in accordance with the Declaration of Helsinki (32).

RESULTS

After classifying the students and evaluating the body composition and PA of HIA adolescents, as a first approximation, we proceeded to evaluate the general characteristics of the sample by sex (Table 1). Significant differences in mass and height were reported between males and females, with males having higher mass ($p < 0.05$) and height ($p < 0.001$) measurements. This sample also shows a high prevalence of eutrophic adolescents (94.12% in males and 76.92% in females), with only 6.65% of adolescents (two males, three females) classified as obese based on BMI. To obtain more accurate information about the body composition of the adolescents, their BF% was evaluated, observing that obesity is higher among females, with a prevalence of 43.59% and only 15.69% among males. Correspondingly, males show significantly higher MM% ($p < 0.001$), with values of approximately 80.06% for males and only 67.56% for females. Thus, significant differences were observed in FMI ($p < 0.001$). There were no significant differences in either scheduled PA hours or PA scores. No significant differences were observed in Tanner stage or SES by sex. In addition, in this sample, the A+B SES category was not observed.

After considering the general characteristics of the adolescents, body composition differences by weekly PA hours were evaluated (Table 2). Most HIA students engage in more than two hours of scheduled PA, specifically 69.86% (n = 51), while only 30.14% (n = 22) engage in less than two hours. Additionally, students who engage in more than two hours of PA show lower FMI ($p < 0.05$) and BF% ($p < 0.05$) and higher MM% ($p < 0.05$). Significant differences in BMI were not observed. However, when variables of body composition were evaluated separately, significant differences appear.

After the adolescents were classified by amount of PA and sex based on the score obtained from the questionnaire (Fig. 1), 26.03% of students had low levels of PA, while 54.79% had regular and 19.18% had high levels. The association between sex and PA is not significant.

Finally, considering the higher prevalence of obesity in females than in males previously shown, a logistic regression was estimated, controlling for PA and SES (Table 3), to determine the association between obesity and sex in HIA students. The results show that females have a high risk of obesity (OR = 7.63; 95% CI: 1.89-30.90).

DISCUSSION

The results of the current investigation indicate that HIA adolescents have a low prevalence of overweight and obesity. As evaluated through BMI, the obesity prevalence is lower than that reported for public schools by JUNAEB, which found that 12.5% of 9th grade students are obese, while only 6.85% of HIA students are obese using the same standards as in our investigation (23). However, in the current investigation, we also defined obesity using BF% because of its relation to NCDs (25). We observed that females exhibit significant higher adiposity ($p < 0.001$) than males, which is consistent with the observations of Moreno et al. (33), Lizana et al. (34), Lizana et al. (35), Camaño Navarrete et al. (36) and Lizana et al. (14). However, male and female participants in the present study reported lower BF% than observed among Chilean adolescents of different SES (14). Thus, we observed sexual dimorphism, with higher adiposity among females, but at lower levels than in other Chilean reports (14).

The amount of PA performed by the HIA students who participated in this study is higher than the amount of PA reported for the general population of Chilean adolescents enrolled in school. In Santiago (Chile), 66% of students in 9th grade engage in less than two hours of PA per week (18). However, only 30.14% of HIA students engage in less than two hours of PA

weekly, which means that these students perform more PA than the amount included in the curriculum and more than is reported by other investigations of students of similar age but who are not HIA students (16,17). This additional activity could be contributing to higher cognitive activity, improved attention and wellness and, hence, to better intellectual performance (4,5). Investigations have demonstrated that students who are physically active have better academic performance (4,5,17,18). Public education policies tend to emphasize the development of mathematical and linguistic abilities to the detriment of PA, despite not following the WHO recommendations for daily PA. Correa-Burrows et al. (18) found that students who engage in a high amount of PA perform better on standardized tests. Specifically, 19.18% of the students in our investigation fall into the high PA category, which is a higher percentage than that reported by Liberona et al. (27), where only 0.7% of students performed high levels of PA.

One limitation of this investigation is that, of the 15 regions in Chile, the students were only drawn from the region of Valparaíso; thus, these results may not be generalizable to the entire school-aged population. Future studies could be performed in other regions and for different age groups. However, all BETA PUCV (HIA) students are from the region of Valparaíso. Another limitation of this study is the use of questionnaires to report PA; moreover, the questionnaire did not include the intensity of exercise. Hence, it would be interesting to conduct this study using accelerometer measures. The findings also suggest that HIA students may be positively influencing their academic performance via their high amount of weekly PA and their high prevalence of normal body composition. With respect to this relation, additional longitudinal studies are required to establish the direction of causality.

Another limitation is that there are no previous data on body composition and PA for HIA students; discussions have focused on data obtained from Chilean student samples that were not necessarily classified by intellectual ability, so we must be cautious in comparing the results.

The results of this study have several implications for schools. Teachers possess scarce knowledge about HIA students and may be taken aback by exceptional students in their subjects, perhaps because most teachers start teaching without knowing about educating talented (gifted) children (37). This research shows that HIA students engage in more PA than their peers, and according to published reports, this could be associated with or foster

their high performance. In Chile, public education policy has increased the work and content in subjects such as Maths and Spanish in the classroom, thus worsening sedentary lifestyles and decreasing hours of PA despite abundant international support for an association between PA and school performance. These results indicate the importance of PA among HIA students and suggest that PA has to be encouraged in educational institutions to develop their talents.

In summary, HIA students engage in more PA than their national counterparts, showing low obesity prevalence. However, obesity is higher in females. This study provides knowledge about the PA of HIA students, showing a possible relation between these two factors.

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Table 1. General characteristics by sex for the sample of 73 gifted adolescents in a talent program in Valparaíso, Chile from April to October 2014

	Male (n = 34)	Female (n = 39)	
	Mean ± SD	Mean ± SD	p-value
Age	16.21 ± 1.12	16.08 ± 1.26	0.649[j]
Intellectual ability[a]	52.76 ± 3.46	51.72 ± 2.82	0.159[j]
Mass (kg)	65.32 ± 11.77	60.19 ± 9.19	0.032[k]
Height (m)	1.72 ± 0.06	1.60 ± 0.06	0.000[j]
BMI (kg/m^2)	22.18 ± 4.14	23.71 ± 3.79	0.056[k]
Nutritional status[b,c]			0.052[l]
Eutrophic	32 (94.12)	30 (76.92)	
Overweight	2 (5.88)	9 (23.08)	
BF(%)[d]	15.69 ± 7.98	28.8 ± 6.30	0.000[k]
Obesity[e,c]			0.001[l]
Non-obese	31 (91.18)	22 (56.41)	
Obese	3 (8.82)	17 (43.59)	
FMI (kg/m^2)[d]	3.77 ± 2.92	7.04 ± 2.67	0.000[k]
Muscle mass (%)[d]	80.06 ± 7.55	67.56 ± 5.96	0.000[k]
Physical activity score[f]	4.76 ± 1.91	4.87 ± 1.96	0.814[j]
Scheduled exercise[g]	4.75 ± 4.53	3.48 ± 2.17	0.125[k]
Physical activity[h,c]			0.164[m]
≤ 2 hours	7 (20.59)	15 (38.46)	
> 2 hours	27 (79.41)	24 (61.54)	
Socioeconomic status[i]			0.507[m]
Medium-high	6 (17. 65)	9 (23.08)	
Medium	6 (17.65)	10 (25.64)	
Medium-low and low	22 (64.71)	20 (51.28)	
Tanner (stage)			0.195[l]
II	3 (8.82)	0 (0.00)	
III	9 (26.47)	11 (28.21)	
IV	16 (47.06)	16 (41.03)	

V	6 (17.65)	12 (30.77)

BMI: Body mass index; BF: Body fat; FMI: Fat mass index. [a]Intellectual ability was evaluated by means of the Raven's progressive matrices test. [b]Data were obtained using the OMS 2007 reference. [c]Data are shown as frequencies (%). [d]Assessed by bioelectrical impedance (TANITA). [e]Definition of obesity: ≥ 25 BF% in boys and ≥30 BF% girls. [f]Score of 0-10 points. [g]Weekly hours: school physical education time and sport extracurricular activities. [i]Obtained by the application of the European Survey (ESOMAR). [j]t-test. [k]Mann-Whitney test. [l]Fisher's exact test. [m]Chi-squared test (Pearson).
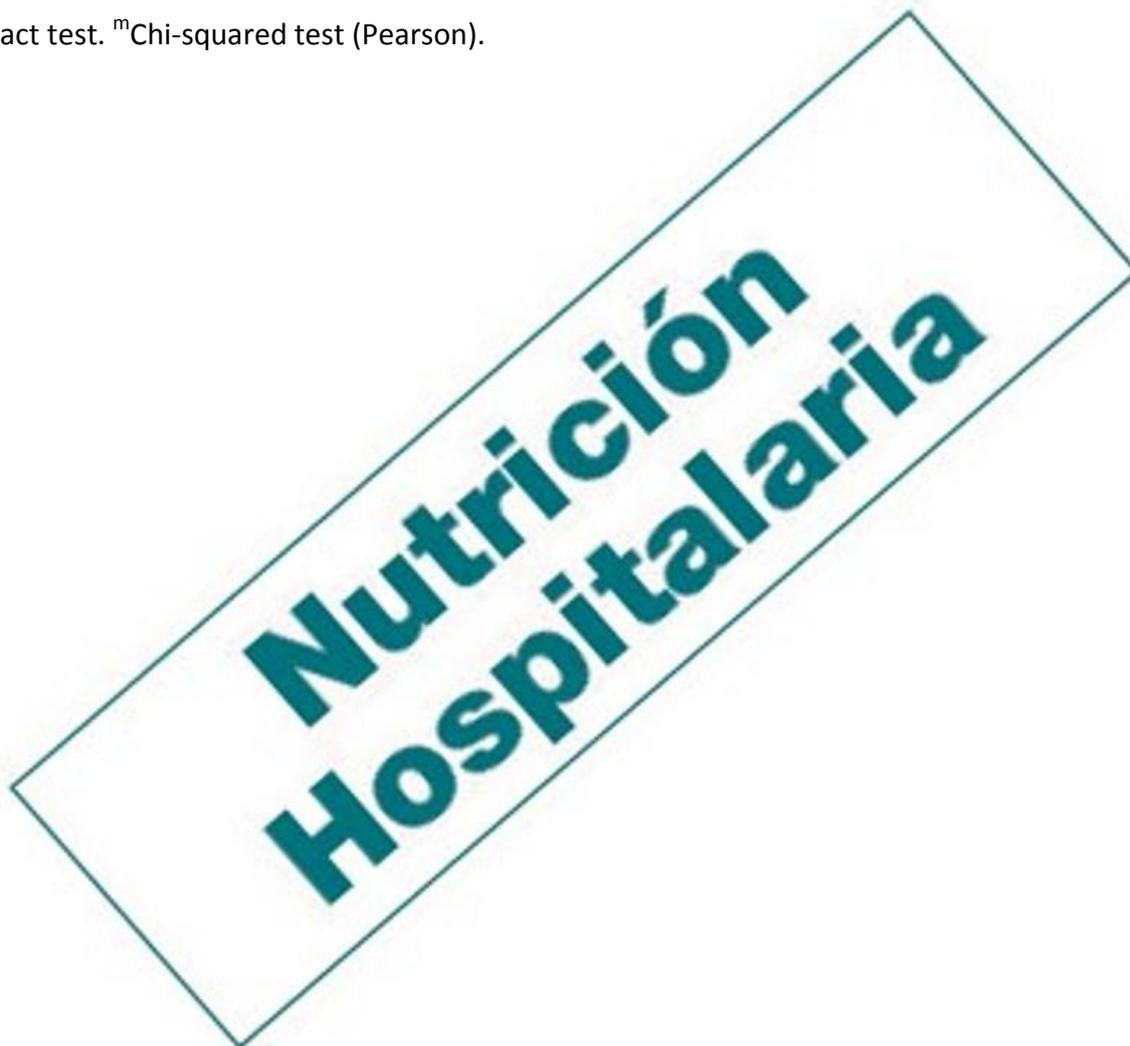
Table 2. General characteristics by amount of physical activity for the sample of 73 gifted adolescents in a talent program in Valparaíso, Chile, from April to October 2014

	≤ 2 hours (n = 22)	> 2 hours (n = 51)	
	Mean ± SD	Mean ± SD	*p*-value
HIA			
Age	16.32 ± 1.21	16.06 ± 1.19	0.398[d]
Mass (kg)	63.73 ± 10.88	62.08 ± 10.70	0.424[e]
Height (m)	1.64 ± 0.09	1.66 ± 0.08	0.353[d]
BMI (kg/m^2)[a]	23.80 ± 3.98	22.65 ± 4.00	0.146[e]
FMI (kg/m^2)[b]	6.48 ± 3.09	5.09 ± 3.21	*0.042[e]*
BF%[c]	26.14 ± 8.53	21.20 ± 9.83	*0.045[d]*
MM%[c]	70.09 ± 8.06	74.79 ± 9.34	*0.044[d]*
Male, n (%)	7 (20.59)	27 (79.41)	
HIA	54.57 ± 3.10	52.29 ± 3.45	0.170
Age	16.14 ± 1.46	16.22 ± 1.05	0.858
Mass (kg)	67.49 ± 11.39	64.77 ± 12.02	0.233
Height (m)	1.72 ± 0.07	1.72 ± 0.06	0.864
BMI (kg/m^2)[a]	22.67 ± 3.09	22.05 ± 4.41	0.259
FMI (kg/m^2)[b]	4.41 ± 1.99	3.60 ± 3.13	0.142
BF%[c]	18.83 ± 7.17	14.87 ± 8.10	0.100
MM%[c]	77.06 ± 6.73	80.83 ± 7.68	0.101
Female, n (%)	15 (38.46)	24 (61.54)	
HIA	51.47 ± 2.47	51.88 ± 3.05	0.672
Age	16.40 ± 1.12	15.88 ± 1.33	0.213
Mass (kg)	62.01 ± 10.58	59.05 ± 8.25	0.387
Height (m)	1.60 ± 0.07	1.59 ± 0.05	0.942
BMI (kg/m^2)[a]	24.33 ± 4.33	23.32 ± 3.46	0.583
FMI (kg/m^2)[b]	7.46 ± 3.09	6.78 ± 2.41	0.624
BF%[c]	29.55 ± 6.92	28.33 ± 5.99	0.697
MM%[c]	66.85 ± 6.53	68.01 ± 5.68	0.729

p < 0.05. [a]BMI: Body mass index; [b]FMI: Fat mass index calculated from bioelectrical impedance (TANITA). [c]Assessed by bioelectrical impedance (TANITA). [d]t-test. [e]Mann-Whitney test.

Table 3. Association between obesity and sex in adolescents with high intellectual ability, controlling for physical activity and socioeconomic status

	High body fat mass *OR (95% CI)*	
Female	*7.63 (1.89-30.90)*	*p = 0.004*
Physical activity	0.72 (0.21-2.40)	*p* = 0.589
High SES	1.74 (0.35-8.60)	*p* = 0.497
Low SES	0.39 (0.09-1.58)	*p* = 0.185
Observations	73	
Chi^2	17.14	
Hosmer-Lemeshow	0.2120	
Correctly classified	78.08%	

OR: Odds ratio; 95% CI: 95% confidence interval; SES: Socioeconomic status.
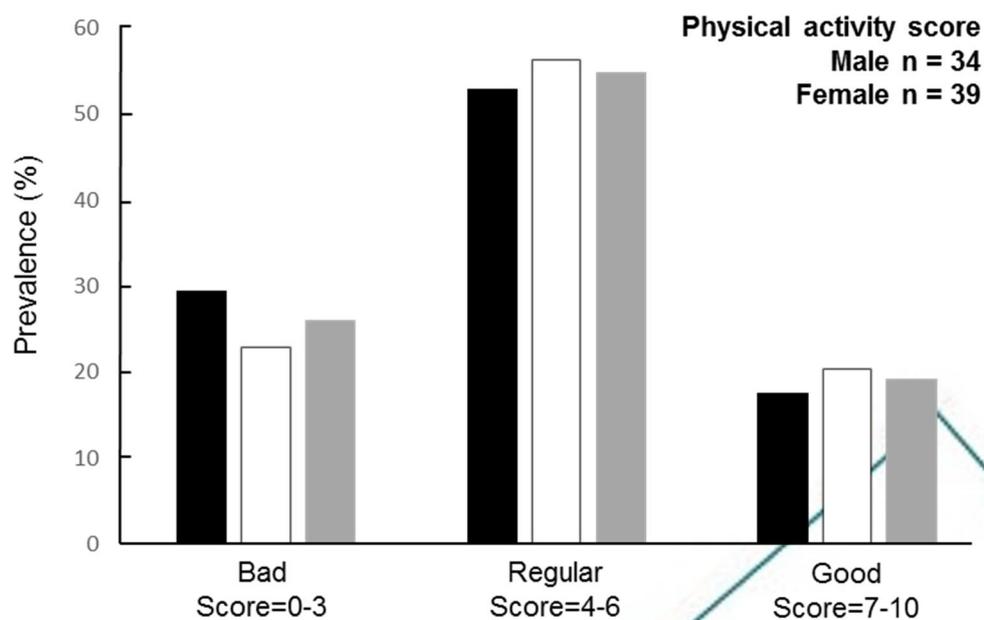
Fig. 1. Rank of physical activity according to sex (black bar = male; white = female) and total sample (gray bar) among high intellectual ability adolescents (aged 14-18 years) from region of Valparaíso, Chile. PA score derived from a questionnaire composed of five items (recumbent, seated, walking, school-based physical activity and sport extracurricular activities).