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Relationship between the motor competence and body mass index in adolescents

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Summary

In this paper, the relationship between different physical indicators that influence the level of motor competence and body mass index (BMI) is analysed. The sample consisted of 959 adolescents aged 12-15 years old, and their average age was 13.59 years (SD = 1.13); 513 (53.5%) were male and 446 (46.5%) were female, andthey all lived in the Spanish region of Aragon. They answered the Sportcomp multidimensional motive battery, which consists of 10 motor tests. Weight and height data were taken to calculate BMI. Low-weight adolescents totalled 11.9%, 27.7% were overweight and 14.1% presented obesity (9.6% obese and 4.5% severely obese). The overall results showed that the normal-weight group achievedgood performance in most tests, more than the obesity groups and more often than the low-weightgroup. However, no differences were observed in the speed, coordination or motor control testswith some low-weightsubgroups stood out in the lateral jump test, while the obesity groups did so in the upper body strength tests, but obtained worse scores in the speed, motor control and coordination tests. However, these groups tended to be more heterogeneous. In gender terms, no intergroup differences appeared in seven of the ten tests, but theydid inthe sit-ups, static equilibrium and 7 metres feet together ones. No differentiated age pattern was found.

Keywords: Body mass index, motor competence, adolescents, age and gender differences.

Relación entre los factores físicos que inciden en la competencia motriz y el índice de masa corporal en adolescentes

Resumen

En este trabajo se analiza la relación entre diferentes indicadores físicos que influyen en el nivel de competencia motriz y el IMC. La muestra se compuso de 959 adolescentes de 12 a 15 años, de los cuales 513 (53.5%) son hombres y 446 (46.5%) mujeres, con una edad media de 13.59 años (DT=1.13), pertenecientes a la Comunidad Autónoma de Aragón. Todos ellos realizaron la batería motriz multidimensional SPORTCOMP, que consta de 10 pruebas motoras, y se les tomaron datos de peso y talla para calcular el IMC. Se encuentra un total de 11,9% de adolescentes con bajo peso, un 27,7% con sobrepeso y un 14,1% con obesidad (9,6% obesos y 4,5% obesos severos). Los resultados globales ponen de manifiesto que el grupo normopeso logra un rendimiento alto en la mayoría de las pruebas, por encima de los grupos de obesidad y más a menudo que el grupo que muestra bajo peso, aunque sin diferencias en las pruebas de velocidad y coordinación y control motor con este último. Algunos sub-grupos con bajo peso destacan en la prueba de saltos laterales, mientras que los grupos de obesidad destacan en pruebas de fuerza del tren superior, pero evidencian una peor puntuación en pruebas de velocidad y de control motor y coordinación. No obstante, estos grupos suelen ser más heterogéneos. Por sexos, las diferencias entre grupos no aparecen en siete de las diez pruebas (todas menos abdominales, equilibrio estático y 7 metros pies juntos), mientras que no se encuentra un patrón evolutivo diferenciado según la edad.

Palabras clave. Índice de masa corporal, competencia motriz, adolescentes, diferencias según edad y sexo.

INTRODUCTION

In the last two decades,sedentary lifestyle has significantly increased (Mülazımoğlu-Ball, 2016; WHO, 2016), andismore marked in females than in males (WHO, 2016), and rises at a higher rate in developed countries than in low-income ones (WHO, 2016). In parallel, an increasing prevalence of overweight and obesity is being verified (Castetbon and Andrevayeba, 2012; Mülazımoğlu-Ball, 2016), and lack of physical activity is one of the predictors of obesity (Ramírez and Agredo, 2012).

A particularly sensitive group is that of adolescents and children as childhood inactivity and obesity are presently a major problem (Mülazımoğlu-Ball, 2016) caused mainly by changes in young people's lifestyle (Castetbon and Andrevayeba, 2012),which tend to continue into adulthood for those who already suffer it (Pardo, 2016).

In an international study on obesity, and in reports and studies published from 1980 to 2013, Ng et al. (2014) analysed and estimated the obesity rate in 2013 in children and adolescents from developed countries. They found 23.8% in males and 22.6% in females, but with 12.9% and 13.4%, respectively, in developing countries. Skinner, Perrin and Skelton (2016) conducted longitudinal research in the USA (1999-2014) and found an overweight rate in adolescents (14 years) of 33.4% (17.4% obesity type I, 6.3% type obesity II and 2.4% severe obesity). Cai, Zhu and Wu (2017) reported a prevalence of being overweight of 14% and 12% for obesity in school populations (primary and secondary education) in China, where it was higher in males than females, and was more likely in urban areas than in rural ones.

Several recent publications on European adolescents' weight status indicate anoverweight prevalence for both genders, which ranged between 17% and 30%, with obesity ranging between 3% and 10%. However, higher percentages werealways found for males in both cases (Jurak, Milanovic, Radisavljevic, Soric and Kovac, 2015, Starc and Strel, 2011). In Spain, we find works like those by Moreno et al. (2005), whose cross-sectional study conducted in five Spanish cities (Granada, Madrid, Murcia, Santander and Zaragoza) obtained a prevalence of overweight + obesity of 25.69% and 19.13% in males and females, respectively.

The enKidstudy (1998-2000), done with a representative Spanish sample aged from 2 to 24 years, showed a prevalence of obesity in Spain of 13.9%, and one of 26.3% for overweight and obesity (12.4% for only overweight), with obesity being higher in males (15.6%) than in females (12%). García-continente et al. (2015) obtained overweight prevalence results of 26.1% for males (6.2% obesity) and20.6% for females (3.7% obesity) in a cross-sectional study with schoolchildren in the city of Barcelona. In some cases, researchers have also included the low-weight category. In the Bulgarian region of Smolyan, Mladenova and Andreenko (2015) studied a sample of 8-15-year olds, and detected a low-weight prevalence of 8% in males and 12.75% in females. In a sample of almost 5,000 adolescents aged 13 years from different Greek regions, Poulimeneas et al. (2016) discovered that 4.1% of adolescents had a BMI below a healthy one. A recently published study conducted in public schools in Brazil used a sample of 10-19-year-old adolescents,and revealed a 2.8% for low weight for males and one of 23% for females (Siqueira et al., 2016). In Spain, De la Cruz-Campos et al. (2016) categorised 320 adolescents into three zones (rural-interior, urban-coastal and urban-interior) and obtained a low-weight prevalence of 10.66% in the rural-interior zone, 19.64% in urban-coastal areas, and 22.86% in the urban-interior area.

In an attempt to understand the underlying causes of the obesity prevalence and an increase in sedentary lifestyle, several researchers have studied the relationship between motor competence, understood as the mastery of physical skills and movement patterns that allows participation in different physical activities (Castelli and Valley, 2007), and body mass index (BMI) according to the premise that motor skills are closely related to active lifestyles (Holfelder and Schott, 2014; Tucker, 2008; Wrotniak, Epstein, Dorn, Jones and Kondilis, 2006).Prskalo, Badrić and Kunješić (2015) identified differences in motor skills among normal-weight, overweight students and obese schoolchildren. Their sample consisted of 333 students from the city of Zagreb aged between 7 and 11 years. The authors concluded that normal-weight children achieved better results in general strength, static strength of arm and shoulder and coordination than their overweight or obese peers. No differences were observed in motor variables when body weight was not a requirement for effective execution. When these authors considered the participants' gender, they explained for motor skills that malesdisplayed better coordination and speed for simple and explosive movements, while females achieved better flexibility. Other research workscame to the same conclusion and detectedmore gross motor problems in obese children. They argued that this could be due mainly to the excess mass they have to mobilise in gross motor tasks as thiswould prevent them from making good movements (D'Hondt, Deforche, De Bourdeaudhuij and Lenoir, 2009; D'Hont et al., 2011; Gentier et al., 2013; Poulsen et al., 2011). Lopes, Stodden, Bianchi, Maia and Rodrigues (2012) conducted research with a sample of youthsaged between 6-14 years old, and found that the normal-weight children of both gendersobtained significantly higher scores for motor competence than the overweight ones, and that the obese children of both genders obtained the lowest motor competence scores of the three weight groups.

Regardingage, an inverse relationship has been found between motor coordination and age as children grow older (D'Huet et al., 2011, Tirado-Rojo, 2016). This correlation does not occur in the early childhood education stage (Logan, Scrabis-Fletcher, Modlesky and Getchell, 2011), althoughGentier et al., (2013)reported differences in gross and fine motor development of children with a healthy weight and those with obesitywhen aged 7-13 years. These authors found that as they grew older, healthy-weight children continued to display a high level of motor performance, while obese children did not overcome increased motor difficulties at older ages. Lopes et al. (2012) found a negative relationship between BMI and motor competence, which lowered over time. Thesame conclusionwas drawn by Okely, Booth and Chey (2004). In their longitudinal research conducted with Australian children, Chivers, Larkin, Rose, Beilin and Hands (2013) observed no significant differences in overall motor performance among the three weight groups at the age of 10. However, when these youths were re-evaluated at the age of 14, the normal-weight group obtained much higher values in motor tests than the overweight and obesity groups.

Indeed many studies have analysed the relationship between physical condition and weight (Casajús, Leiva, Villarroya, Legaz, and Moreno, 2007, De la Cruz-Campos, 2016, Dumith, Ramires and Souza, 2010), or between one-dimensional motor competence and body weight (D'Hont et al., 2009; Gentier et al., 2013; Poulsen et al., 2011). However, we did not find any studies that linked motor competence, analysed from a multidimensional perspective, with overweight and obesity. The theoretical basis on which the multifactorial study is based focuses on European current contributions that divide the factors into which basic motor skills are divided into conditional capacities and coordinative capacities (García, Navarro and Ruiz, 1996). It also focuses on contributions from the American current, such as Gallahue and Ozmun (2006), who indicate that physical factors affect the development of movement skills in all motor development phases, of which thereare two types: physical fitness (strength, flexibility, aerobic resistance) and motor fitness (speed, agility, coordination, balance). Therefore, the objective of this work is to analyse the relationship between motor competence, evaluated from a multidimensional perspective, and BMI according to gender and age.

METHOD

Participants

The participants of this study were young adolescents aged from 12 to 15 years, who were all students from the Spanish Autonomous Community of Aragon. The sample was obtained by a random procedure in which theprovince (Huesca, Zaragoza and Teruel) and the course (Years 1-4 of ESO; Compulsory Secondary Education) were taken as strata. Thus with a sampling error of plus/minus 3% for 95% confidence intervals in the case of P=Q=0.5, a sample size of 1,048 individuals remained, which lowered to 959 after eliminating those participants who did not perform all the tests. In the final sample, 513 (53.5%) were males and 446 (46.5%) were females.The final average age of the sample was 13.59 years (SD = 1.18). The percentage of males and females in each age group was not statistically different ($\chi 2 = 2.780$, $p = .427$).

Variables and instruments

To assess motor competence (MC),we used the Multidimensional Motor Competition battery SPORTCOMP (Ruiz et al, 2010). The purpose of using this battery was to provide a tool for Physical Education teachers in ESO to verify the MC of their students, and to adapt teaching according to the results. The battery consists of 10 tests subdivided into two groups: five for motor fitness (flexibility with extended legs to reach as far as possible in the drawer, medical ball of 2 kg throwing, maximum number of sit-ups in 30 ", manual dynamometry with dynamometer, and making a round-trip in a space of 9 metres twice), and five for coordination and motor control (one-foot equilibrium time with closed eyes up to a maximum of 60 seconds, travelling a displacement of 3 metres on two small supports, completing a distance of 7 metres with jumps feet together, walking seven metres by hopping and making the maximum number of lateral jumps for 15").Weight was obtained using a digital scale with a precision of 0.05 kg. Height was measured by an anthropometric tool with a precision of 0.1 cm, according to the prescription of Gordon, Chumlea and Roche (1988). BMI was calculated using the formula that divides measured weight in kilograms by height measured in square metres as kg/m^2. After collecting the BMI data, the participants were categorised following the reference pattern by age for schoolchildren and adolescents aged from 5 to 19 years published by the WHO in 2007. According to this pattern and standard deviation, this established six groups: overweight ($\geq + 1$ to $+ 1.9$), obesity ($\geq + 2$ to $+ 2.9$), severe obesity ($\geq + 3$), normal-weight ($+ 0.9$ to $- 0.9$), low-weight ($\leq - 1$ a - 1,9) and malnutrition ($\leq - 2$).

Procedure

In the first place, the education centres selected for sampling were contacted. After firstly contacting the management of these centres and the Physical Education departments, and having obtainedtheir approval to participate in the research, families were contacted to request their authorisationin such a way that all those who participated in ourresearch had their families' consents. Data were anonymously processed. A calendar to apply tests was fixed. Sportcomp was executed individually and outside the rest of the class. All the tests were applied by future graduates in Physical Activity and Sports Sciences after being trained in the research, and also in the specific way of applying the content of tests.

RESULTS

The participants in this study obtained a value of 21.45 (3.69) for their BMI, with no gender differences ($F_{1,957}$= 0.174, p = .676). However,genderdifferences were found with the motor competence indicators (Table 1). So in all the tests except the flexibility test (wherefemales reachedmorecentimetreson the bank and, therefore, obtained higher scores) and in the lateral jump test (with no differences between both groups), males obtained better scores (they threw the medicine ball further, did more sit-ups in 30", didmore kilograms of static force, did the round-trip tests, 7 metres hopping, 7 metres feet together and supports in less time, and they held the one-foot balance longer than females). Age differences were observed between the four considered adolescent groups, with a tendency for improved motor competence in all the tests in which there were differences, except for the one-foot equilibrium test,for which this circumstance did not occur.

Table 1. Sportcom ANOVA by Gender

	Gender	Mean	*SD*	Brown-Forsythe	η^2
Flexibility	Boys	15.38	7.57	127.492***	.118
	Girls	21.03	7.86		
Medicine ball	Boys	628.79	142.39	346.219***	.252
	Girls	491.28	82.06		
ABS	Boys	25.51	5.11	123.777***	.114
	Girls	21.92	4.86		
Dynamometry	Boys	31.51	8.85	182.249***	.150
	Girls	25.42	4.75		
Round-trip	Boys	11.09	1.08	218.829***	.186
	Girls	12.11	1.05		
Balance	Boys	2.14	0.79	.892	.001
	Girls	2.09	0.81		
Supports	Boys	14.94	3.14	43.779***	.044
	Girls	16.36	3.43		
7 metres hopping	Boys	2.17	0.38	123.357***	.114
	Girls	2,43	0.37		
7 metres feet together	Boys	2,47	0.41	138.254***	.131
	Girls	2,84	0.55		

Lateral jumps	Boys	39,24	14.00	4.522*	,005
	Girls	37,31	14.04		

When considering BMI, we verified that 46.3% of the adolescents fell within their ideal weight range, with 11.9% and 27.7% forthe low-weight group and the overweight group, respectively. According to the followed procedure, it was striking to find a group of youthswith a higher BMI because 9.6% obtained obesity values and 4.5% had severe obesity values. This distribution did not showany statistically significant differences in the various age and gender groups ($\chi 2 = 2.043$, p = .728).

The results of analysing the relationship among the motor competence indicators, the BMI valuesand gender are shown in Table 2. In both cases, andin multivariate terms, an interaction was observed between the BMI and gender groups Root major of Roy $F_{20, 943} = 3.252$, p <.001, $\eta^2 = .033$) and BMI and age (Root major of Roy $F_{12, 938} = 4.589$, p <.001, η^2 =. 055), as well as main effects for the BMI groups (Root major of Roy $F_{10,932} = 27.350816$, p <.001, $\eta^2 = .227$), gender (Root major of Roy $F_{10, 944} = 37.096$, p <.001, $\eta^2 = .283$) and age (Root major of Roy $F_{10,931} = 16,677$, p <.001, $\eta^2 = .152$).

Table 2. Analysis of BMI variance: Indicators of motor competence according to gender or age

	Total sample		Gender				Age							
			Boys		Girls		12		13		14		15	
	F	η2	F	η2	F	η2	F	η2	F	η2	F	η2	F	η2
Flexibility	1.007	.004	1.176	.009	.190	.002	1.188	.021	.689	.013	3.126*	.052	1.455	.021
Medicine ball	5.523***	.023	4.017**	.031	4.942***	.043	3.340*	.057	1.665	.030	2.729*	.046	3.960**	.054
ABS	3.898**	.016	5.481***	.041	1.432	.013	.702	.013	.872	.016	2.032	.035	3.282*	.045
Dynamometry	12.379***	.049	8.269***	.061	9.366***	.078	6.510***	.010	2.467*	.044	4.896***	.079	6.047***	.080
Round-trip	11.262***	.045	10.063***	.073	3.763*	.033	2.096	.037	3.885**	.067	6.479***	.102	2.906*	.040
Balance	3.334**	.014	5.586***	.042	1.051	.009	.525	.009	.094	.002	4.023**	.066	2.161	.030
Supports	12,119***	,048	9,954***	,073	3,470**	,031	3,769**	,064	3,099*	,055	4.259**	.070	6.149***	.082
7 metres hopping	9.805***	.040	8.595***	.063	4.672***	.041	3.755**	.064	5.915***	.099	4.486**	.073	2.785*	.039
7 metres feet together	2.178	.009	2.023	.016	1.583	.014	1.543	.027	2.940*	.052	1.003	.017	.711	.010
Lateral jumps	7.461***	.030	5.960***	.045	2.939*	.026	1.775	.031	1.592	.029	5.422***	.087	1.427	.020

*≤.05, **≤.01, ***≤.001

Initially, the results were shown for the total group and were analysed by the gender and age groups for the tests that were statistically significant in univariate terms. Tables 3 and 4 provide the results of the ANOVAS of each group and the means of the different groups. With the total group, we found differences in all Sportcom tests according to the BMI groups (Table 2), except for flexibility and 7 metres feet together, where the effect sizes being bigger in dynamometry ($\eta^2 = .049$), supports ($\eta^2 = .050$), 7 metres hopping ($\eta^2 = .048$) and round-trip ($\eta^2 = .045$). The *post hoc* comparisons indicated that the low-weight group differed from the rest for the upper body strength tests (medical ball throwing and dynamometry) with lower performance than the other groups, while the lateral support and jumps obtained the most positive motor results.The severe obesity group differed in sit-ups (Table 3) and didthe fewest repetitions. We also observed that the obesity groups obtained the worse values than the normal BMI in several tests that required measuring performance time (round-trip, supports, 7 metres leg) and in the lateral jumps, especially for the severe obesity group.

When analysing data according to gender, we found an interaction with the BMI groups in the sit-up tests ($F_{4,948} = 2.825$, p = .024, $\eta^2 = .012$), balance ($F_{4.948} = 3.112$, p = .015, $\eta^2 = .013$) and seven metres straight leg ($F_{4,948}= 2.519$, p = .040, $\eta^2 = .011$). In these cases, the interaction result indicatedintergroup differences only for males in the sit-ups and balance tests, and no such differenceswere found for females (Table 2).

Thus the multiple comparisons made of the balance and sit-up tests showed that the severe obesity group performed less in both tests, and maintained the one-foot equilibrium position for less time and did fewer sit-ups in 30 seconds. In the 7 metres hopping test, the two low-weightgroups (normal and low weight) performed more than the others as they managed more jumps. For the female gender, the two heaviest groups (obesity and severe obesity) were the worst performers. The descriptive results are shown in Table 3.

Table 3. Means and Standard deviations of the BMI groups for the total sample and for boys and girls.

		TOTAL			BOYS			GIRLS		
		N	Mean	*SD*	N	Mean	*SD*	N	Mean	*SD*
	- 1 SD	114	17.81	7.91	60	14.46	7.34	54	21.53	6.82
	NORMAL	444	17.62	8.38	245	15.13	7.65	199	20.68	8.25
Flexibility	+1 SD	265	18.85	8.34	133	16.54	7.81	132	21.17	8.24
	+ 2 SD	92	17.63	7.66	52	14.70	7.25	40	21.44	6.48
	+3 SD	43	18.06	7.24	23	15.35	6.45	20	21.18	6.96
Medicine ball	- 1 SD	114	518. 42	106, 80	60	572.17	109.03	54	458.70	64.66
	NORMAL	444	563.60	138.58	245	627.76	142.60	199	484.62	80.93
	+1 SD	265	569.92	131.55	133	634.21	141.97	132	505.15	78.39
	+ 2 SD	92	600.65	148.37	52	661.35	151.23	40	521.75	100.81
	+3 SD	43	593.02	162.84	23	682.61	161.28	20	490.00	87.24
ABS	- 1 SD	114	23.75	5.21	60	24.93	5.06	54	22.43	5.10
	NORMAL	444	24.18	5.36	245	26.28	4.99	199	21.60	4.63
	+1 SD	265	23.75	5.28	133	25.20	5.04	132	22.30	5.13
	+ 2 SD	92	24.01	5.19	52	25.10	5.51	40	22.60	4.42
	+3 SD	43	20.88	4.67	23	21.52	4.02	20	20.15	5.32
Dynamometr.	- 1 SD	114	24.86	5.86	60	27.11	6.49	54	22.36	3.77
	NORMAL	444	28.31	7.54	245	30.87	8.41	199	25.16	4.66
	+1 SD	265	29.55	8.11	133	32.58	9.57	132	26.48	4.63
	+ 2 SD	92	31.46	7.71	52	34.80	8.08	40	27.14	4.40
	+3 SD	43	31.21	10.04	23	36.04	10.56	20	25.65	5.73
Round-trip	- 1 SD	114	11.47	1.05	60	11.00	1.04	54	12.00	0.78
	NORMAL	444	11.37	1.15	245	10.85	0.93	199	12.00	1.06
	+1 SD	265	11.77	1.20	133	11.35	1.20	132	12.19	1.06
	+ 2 SD	92	11.65	1.05	52	11.28	1.00	40	12.13	0.90
	+3 SD	43	12.40	1.39	23	11.97	1.22	20	12.90	1.44
Balance	- 1 SD	114	2.18	0.86	60	2.11	0.77	54	2.28	0.95
	NORMAL	444	2.19	0.83	245	2.28	0.84	199	2.08	0.82
	+1 SD	265	2.02	0.71	133	2.02	0.68	132	2.01	0.74
	+ 2 SD	92	2.04	0.80	52	1.99	0.75	40	2.11	0.86
	+3 SD	43	1.89	0.70	23	1.66	0.64	20	2.15	0.70
Supports	- 1 SD	114	14.73	2.62	60	13.90	2.45	54	15.66	2.51
	NORMAL	444	15.14	2.90	245	14.43	2.60	199	16.02	3.00
	+1 SD	265	16.15	3.61	133	15.56	3.65	132	16.74	3.49
	+ 2 SD	92	16.28	3.79	52	15.94	3.39	40	16.72	4.24
	+3 SD	43	17.86	4.86	23	17.35	3.95	20	18.44	5.79
7 metres hopping	- 1 SD	114	2.25	0.37	60	2.16	0.40	54	2.35	0.32
	NORMAL	444	2.23	0.36	245	2.08	0.30	199	2.41	0.35
	+1 SD	265	2,33	0.40	133	2.25	0.44	132	2.42	0.33
	+ 2 SD	92	2.42	0.42	52	2.32	0.35	40	2.56	0.47
	+3 SD	43	2.50	0.49	23	2.33	0.39	20	2.69	0.52
7 metres feet together	- 1 SD	114	2.61	0.39	60	2.73	0.37	54	2.73	0.37
	NORMAL	444	2.60	0.48	245	2.83	0.51	199	2.83	0.51
	+1 SD	265	2.68	0.60	133	2.88	0.66	132	2.88	0.66
	+ 2 SD	92	2.65	0.45	52	2.80	0.44	40	2.80	0.44
	+3 SD	43	2.80	0.66	23	3.07	0.76	20	3.07	0.76

Lateral jumps	- 1 SD	114	42.25	14.94	60	41.95	14.41	54	42.57	15.64
	NORMAL	444	39.30	13.55	245	41.00	14.43	199	37.22	12.11
	+1 SD	265	37.64	14.58	133	38.31	13.21	132	36.97	15.86
	+ 2 SD	92	33.83	12.11	52	34.17	11.18	40	33.38	13.37
	+3 SD	43	32.28	12.94	23	30.26	12.53	20	34.60	13.33

In the other tests, the pattern of differences was no different between males and females, with the only difference being a larger effect size for males in the round-trip test (η^2 = .073 *vs.*η^2 = .033) and in lateral jumps (η^2 = .045 *vs.*η^2 = .026).

The relationships between age and BMI are shown in Tables 2 and 4. We firstly found an interaction between the age group and the flexibility tests ($F_{12,938}$ = 1959, p = .025, η^2 =. 024) and for the 7 metres hopping ($F_{12, 948}$ = 2.009, p = .021, η^2 = .025). In the flexibility test, differences were found only in the 14-year-old group ($F_{4.231}$ = 3.126, p = .016, η^2 = .052) in which the overweight group [22.23 (8.80)] scored more than the normal-weight group [17.68 (9.42)]. For the 7-metre leg test, intergroup differences appeared for all ages, but were more relevant in the 14- and 15-year-old groups because the groups of less than one standard deviation and the normal group differed from the groups with a higher BMI.

Table 4. Means and Standard deviations of BMI groups in age groups

		12 Years old			13 Years old			14 Years old			15 Years old		
		N	Mean	*SD.*	N	Mean	*SD*	N	Mean	*SD*	N	Mean	*SD*
Flexibility	- 1 SD	26	14.21	7.96	17	17.38	7.21	35	17.60	7.62	36	20.80	7.58
	NORMAL	109	16.74	7.56	107	16.47	7.77	102	17.68	9.42	126	19.31	8.49
	+1 SD	56	15.29	7.78	71	16.12	7.70	60	22.23	8.80	78	21.28	7.13
	+ 2 SD	22	16.45	6.13	16	17.69	5.24	23	17.17	9.80	31	18.77	8.06
	+3 SD	11	19.18	10.24	9	20.06	5.34	12	16.58	7.59	11	16.91	4.48
Medicine ball	- 1 SD	26	460.77	77.40	17	491.18	94.60	35	540.86	110.44	36	551.11	110.34
	NORMAL	109	469.54	81.55	107	531.50	100.73	102	608.43	121.73	126	635.95	161.94
	+1 SD	56	480.00	78.28	71	538.73	99.00	60	626.17	139.95	78	619.62	138.91
	+ 2 SD	22	506.36	94.29	16	573.75	139.66	23	606.52	103.70	31	677.10	173.04
	+3 SD	11	550.91	106.25	9	497.78	87.15	12	596.67	150.90	11	709.10	209.78
ABS	- 1 SD	26	22.62	3.98	17	24.59	6.29	35	23.89	4.98	36	24.03	5.73
	NORMAL	109	22.37	4.70	107	23.00	5.18	102	25.88	4.64	126	25.37	5.89
	+1 SD	56	21.61	4.21	71	22.54	5.21	60	25.08	5.26	78	25.38	5.30
	+ 2 SD	22	22.55	6.21	16	23.25	4.60	23	25.00	4.34	31	24.71	5.22
	+3 SD	11	20.46	5.41	9	21.00	3.12	12	22.58	4.76	11	19.36	4.82
Dynamometry	- 1 SD	26	21.42	3.97	17	23.76	3.78	35	26.33	6.17	36	26.43	6.49
	NORMAL	109	22.67	4.87	107	26.93	6.31	102	31.06	7.23	126	32.15	7.38
	+1 SD	56	24.41	4.93	71	27.31	6.11	60	32.95	7.82	78	32.65	9.21
	+ 2 SD	22	26.95	4.34	16	30.13	6.39	23	31.85	6.07	31	35.08	9.50
	+3 SD	11	26.91	7.40	9	28.78	6.36	12	31.83	8.50	11	36.82	14.01
Round-trip	- 1 SD	26	11.88	0.81	17	11.42	1.04	35	11.40	0.97	36	11.28	1.23
	NORMAL	109	11.93	1.03	107	11.56	1.11	102	11.00	0.88	126	11.01	1.23
	+1 SD	56	12.33	1.43	71	11.94	1.02	60	11.39	1.06	78	11.49	1.11
	+ 2 SD	22	12.20	0.96	16	11.72	0.83	23	11.51	0.90	31	11.33	1.18
	+3 SD	11	12.62	1.02	9	12.78	1.45	12	12.34	1.12	11	11.95	1.91
Balance	- 1 SD	26	2.21	0.93	17	2.16	0.72	35	2.23	0.74	36	2.15	1.00
	NORMAL	109	2.11	0.77	107	2.05	0.86	102	2.38	0.93	126	2.23	0.76
	+1 SD	56	1.98	0.74	71	2.09	0.68	60	1.90	0.74	78	2.06	0.69
	+ 2 SD	22	2.00	0.68	16	2.05	0.97	23	2.01	0.77	31	2.09	0.84
	+3 SD	11	2.13	0.88	9	2.07	0.77	12	1.83	0.59	11	1.56	0.49

Supports	- 1 SD	26	15.60	2.40	17	14.55	2.50	35	14.67	2.79	36	14.26	2.63
	NORMAL	109	16.96	3.00	107	15.47	3.06	102	14.25	2.36	126	14.01	2.15
	+1 SD	56	18.38	4.17	71	16.13	2.60	60	15.75	3.63	78	14.87	3.28
	+ 2 SD	22	17.76	2.95	16	17.02	3.46	23	15.49	4.44	31	15.43	3.71
	+3 SD	11	17.88	3.02	9	17.96	4.89	12	17.26	3.39	11	18.41	7.58
7 metres hopping	- 1 SD	26	2.22	0.26	17	2.25	0.28	35	2.26	0.48	36	2.27	0.38
	NORMAL	109	2.42	0.38	107	2.23	0.36	102	2.10	0.33	126	2.17	0.31
	+1 SD	56	2.56	0.48	71	2.31	0.29	60	2.27	0.43	78	2.25	0.34
	+ 2 SD	22	2.54	0.33	16	2.50	0.48	23	2.38	0.40	31	2.33	0.46
	+3 SD	11	2.43	0.44	9	2.74	0.49	12	2.41	0.39	11	2.46	0.62
7 metres feet together	- 1 SD	26	2.65	0.37	17	2.62	0.28	35	2.57	0.41	36	2.62	0.45
	NORMAL	109	2.75	0.50	107	2.66	0.53	102	2.48	0.36	126	2.53	0,47
	+1 SD	56	2.96	0.90	71	2.63	0.40	60	2.58	0.56	78	2.61	0.48
	+ 2 SD	22	2.75	0.40	16	2.70	0.43	23	2.63	0.44	31	2.58	0.49
	+3 SD	11	2.78	0.42	9	3.19	0.68	12	2.58	0.34	11	2.73	0.97
Lateral jumps	- 1 SD	26	37.85	9.35	17	44.35	17.76	35	45.66	16.28	36	41.11	15.06
	NORMAL	109	41.03	12.82	107	40.08	13.57	102	40.49	15.27	126	36.19	12.27
	+1 SD	56	37.75	13.00	71	39.99	14.56	60	36.83	13.36	78	36.05	16.45
	+ 2 SD	22	34.82	9.92	16	34.31	15.24	23	31.48	9.68	31	34.61	13.63
	+3 SD	11	35.27	16.94	9	32.56	13.33	12	29.58	10.06	11	32.00	12.02

For all the other tests, the analysis of the different age groups showed some intergroup differences as follows:in the medicine ball test, there were two age groups, 12 and 15 year olds, in which the most overweight youngsters (+ 3SD) scored more than the rest. However, the other groups presented a similar pattern to the low-weight youths and obtained lower scores than the rest (Table 4).

For sit-ups (Table 4), no differences were found between the age groups under the ageof 15,after which the more overweight group (+3 SD) scored significantly less than the rest ($p < .05$).

For dynamometry, the low-weightgroups (-1SD) obtained the lowest scores in the 14- and 15-year-old groups (Table 4). At this age, they clearly differentiated from the normal-weight group, but their values were similar to this low-weightgroup at the ages of 12 and 13 years.

For the round-trip, some minimal differences were observed between groups at the agesof 14 and 15 years (Table 4), where the normal-weight group better performed than the heavier weight groups. The same can be stated of balance, a test in which the older groups and the more overweight participants (+ 3SD) differed from the rest. One particular finding was that the 14-year-old normal-weight groupperformed poorlyin this test.

In the supports test, the most striking aspect was the general decline with age as the overweight groups obtained lower values in this test, the most overweight ones did at older ages (+ 3SD), and the overweight ones (+ 1SD) at the age of 12. Among the youngest participants, the low-weight group (-1SD) also obtained the best results, and were surpassed by the normal-weight group aged 14 and 15 years.

Finally in the 7 metres feet together test, we found that the group with the highest BMI (+ 3SD) in the 13-year-old groupperformed worse than the rest. However, this pattern did not occur for the other age groups. Something similar happened with lateral jumps as the older groups, i.e., adolescents with a higher BMI, tended to perform worse in this test.

DISCUSSION

Although our main study objective was to verify the relationship between motor competence and BMI in a sample of Spanish adolescents, one of the most striking circumstances was the distribution of BMI, especially for the groups above the normal weight, which represented 41.8 % of the total sample (27.7% overweight, 9.6% obesity and 4.5% severe obesity). These data were much worse than those recorded in the Spanish studies cited herein (García-Continente, 2015; enKid study, 2000; Moreno et al., 2005) and revealed an increasing evolution towardsbeing less healthy and overweight, and higher obesity rates. These indiceswere also higher than those recorded in other European (Jurak et al., 2015, Starc and Strel, 2011) and internationalstudies (Cai et al., 2017; Ng et al., 2013), and came very close to the conclusions reached by

Skinner et al. (2016) with a US American adolescent population aged 14yearsin their longitudinal study. Moreover, our study results do not match the differences in excess weight between genders with other studies, which have shown that this is higher in males than in females (Cai et al., 2017, enKid, 2000, García-continenete, 2016, Jurak et al. al., 2015; Moreno et al., 2005; Starc and Strel, 2011). Ourdata revealheavier weightsfor the female participants, with 43.13% (29.66% overweight, 98% obesity and 4.49% severe obesity) of females weighing more than the 40.53% of males (25.92% overweight, 10.13% obesity and 4.48% severe obesity). Only Ng et al., (2013) came close to these data as their weight levels were similar for both genders. This higher than normal increase in body mass indices in our sample ofadolescents was one of the most important factors to explain the increasing overweight and obesity rates found in our research compared to others. However, it is worth explaining that some comparative studies (Caiet al., 2017; EnKid, 2000; Ng et al., 2013) have also includedwider age groups, as well aschildren and not just adolescents.

Regarding low weight rates, we found some rates at around 11.9%, which is similar to the conclusions ofMladenova and Andreenko (2015) in their population of Bulgarian adolescents, are higher than those obtained by Poulimeneas (2016) with Greek students aged 13 years, and are much more positive than the values reported by García-continente (2016) in adolescents from south Spain compared to two of the areas that their study was divided into: urban-urban and interior-urban. The differential factor of the data that we show is that no differences exist between the group of males and females, with 11.69% and 12.13% respectively, as the low-weightrate in the female group is higherin most studies (Mladenova and Andreenko, 2015, Siqueira et al., 2016).

Regarding the main objective, differences in the overall sample were found for all the tests according to the BMI groups, except for flexibility and 7 metres feet together, with higher effect sizes found in dynamometry, supports, 7 metres leg and round-trip. MCbecame worse in most of the speed/agility tests and for coordination/motor control for the subjects who belonged to the obesity and severe obesity groups compared to the normal- and low-weight groups. This supports the conclusions of D'Hondt et al. (2009), D'Hont et al. (2011), Gentier et al. (2013), Poulsen et al. (2011) and Lopes et al. (2012), who detected bigger difficulties in gross motor tasks in young and overweight children by arguing that they move differently because of their additional mass.

However, the obese groups obtained good results in the upper body strength tests, and equalled and, in some cases, were superior, to the normal-weight group, and were significantly better than the lower-weight group. Accordingly, contradictory results were found. On the one hand, our data were consistent with the studies carried out with children and adolescents in which grip strength was greater in overweight and obese students (Artero et al., 2010, Casajús et al., 2007, Mayorga-Vega, Brenes, Rodríguez and Merino, 2012), as was launching the medicine ball (Dumith et al., 2010). On the other hand, there are other studies,which have also used thesetests, in which the normal-weight group obtained better motor efficiency (Bovet, Auguste and Burdette, 2007, Prskalo et al. , 2015; Zivkovic et al., 2014). The lower-weight group obtained lower motor values than the other groups in the upper body strength tests, probably due to lack of muscle mass, which is superior in the motor test of lateral jumps. This isprobably caused by what Cools, Martelaer, Samaey affirmed and Andries (2011) and Okely (2004) et al. explained when they reported a significant relative strength and less difficulty moving their mass against gravity.

When analysing the relationship between genders and the mechanical factors that affect MC and BMI, differences between the BMI groups were found in all the tests for males, except for flexibility and 7 metres feet together, where the lower-weight adolescents obtained worse results in the physical condition tests related to upper body strength. Males with severe obesity were those who performed fewer repetitions in 30 seconds in the sit-up test, in the speed test and in four of the five coordination and motor control tests, including one-foot balance.

The evolution for females was similar to the pattern established in the general group, and our data match works like those by Lopes et al. (2012) on speed/agility and coordination and motor control tests. They reported that severe obesity adolescents obtained the lowest motor score. However in the upper-body strength tests, the overweight students obtained high values, and data were consistent for both genders. Regarding behaviour in different tests, we highlight the differences according to BMI in balance and sit-ups, whereintergroup differences appeared only for males, andnot for females. In all the other tests, the results resembledthose of the general sample.

According to age, we did not find such a clear pattern as that observed in the data analysis regarding gender. The 7-metre hopping test was the only test torevealintergroup differences for all ages, where the low-weight group was that which presented the best competence. It is noteworthy that at the age of 12 years, no significant differences appeared among the BMI groups in the different tests, and differences were found only at the age of 14, and also at15, but to a lesser extent, and mainly for the coordination and control and motor tests. This underlies the disagreement with conclusions such as those drawn byGentier et al. (2013), Lopes et al. (2012) and Okely (2004), who indicated that differences between the normal-weight groups and obesity groups did not increase with age, although it is true that the overweight group is not fully included in this increase.

This study reveals that the low-weightadolescent group did not show any deficiencies in MC, but it may be important to take measures for them to increase their mass and to avoid the future possibility of health problems caused by being below an adequate weight. We observed differences for overweight high school students, especially in tests that require speed, coordination and motor control, which may imply having abandoned physical activity. In line with this, Goulardis, Marques, Casella, Nascimiento and Oliveira (2013) have shown that those children and adolescents with motor problems tend to participate less in physical activities for fear of failure or criticism. Moreover, we should not forget the close relationship between motor skills and active lifestyles (Holfelder and Schott, 2014; Tucker, 2008; Wrotniak et al., 2006).

Authors such as Nishida (2007) have demonstrated that generating a positive motivational and emotional climate will influence motor elements, such as motor learning, effort in both practice and persisting in this practice, and in the perception of competence and physical performance in sports. Factors such as MC have a positive relationship with sports practice, as explained in the previous paragraph, but the MCperception isalso significantly linked with the desire to practice, and with interest in maintaining this practice over time (Khodaverdi, Bahram, Khalaji, Kazemnejad, 2013, Urrutia-Gutiérrez, Otaegi-Garmendia and Arruza, 2017).

Our study indicates a small window that allows intervention since the good performance noted in the strength and upper body tests endorses the use of strategies and effective programmes to avoid sedentary lifestyles as theaforementioned factors can be approached. These programmes should form part of the Physical Education subject and in sports-base classes, where strength has an important value for these heavier-weight groups either by performing tasks directly related to upper body strength or playing roles or subroles in activities and sports in which this force can facilitate success. These measures may favour obese students' greater enjoyment and perception of competence, which are requirements to avoid athletic abandonment and being less engaged in Physical Education classes.

We must finish with some of the most important study limitations. On the one hand, we highlight the fact that this is a cross-sectional study, which limits causal relationships between the analysed variables. On the other hand, there is the fact that we worked with a narrow age group, which does not allow us to extrapolate the results to a larger number of children and adolescents. Finally, another significant limitation was the configuration of the MC, which sometimes meansthat the different configured groups are not discriminated in the variables of flexibility, one-foot balance and lateral jumps, which could be analysed in the future.

CONCLUSION

The normal-weight group achieved good performance in most tests, more than the obesity groups and more often than the low-weight group. However, no differences were observed in the speed, coordination or motor control tests with some low-weight subgroups stood out in the lateral jump test, while the obesity groups did so in the upper body strength tests, but obtained worse scores in the speed, motor control and coordination tests. In gender terms, no intergroup differences appeared in seven of the ten tests. No differentiated age pattern was found.

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