Original article (short paper)

The relationship between segmental coordination, agility and physical activity in adolescents

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Abstract—Motor competence (MC) may be related to youth physical activity (PA) level. In the last few years, MC has been studied as a possible determinant of children PA level, but has not been widely studied in adolescents. To analyze the relationship between MC and PA level 533 adolescents (271 men and 261 women) from the southeast of Spain were assessed. To register weekly PA was used the International Physical Activity Questionnaire (IPAQ) and for the MC, four coordination tests including throw and catch test, eye-hand and eye-foot coordination tests and agility circuit. Data were analyzed using ANOVA and binary logistic regression. The overall MC is consistently related with PA level. Eye-hand coordination test and the agility test define more accurately the tendency to high PA level. Programs to promote PA and focused on MC should be emphasized from early ages to adolescence.

Keywords: motor competence, physical activity, adolescents, public health

Resumo—"Relação entre a coordenação segmentar, agilidade e atividade física em adolescentes." A competência motora (CM) pode estar relacionada com o nível de atividade física (PA) dos jovens. Nos últimos anos, a CM infantil tem sido estudada como possivel determinante do nível de AF, mas ainda não foi extensivamente estudada em adolescentes. Para analisar a relação entre o nível de AF e competência motora foram avaliados 533 adolescentes (271 homens e 261 mulheres), no sudeste de Espanha. Para registar a AF semanal empregou-se o Questionário Internacional de Atividade Física (IPAQ), e para a CM quatro testes de coordenação, incluindo lançamento e recepção, coordenação óculo manual e óculo pedal e um percurso de agilidade. Os dados foram analisados usando a análise de variância e a análise de regressão logística binária. A competência global motora revelou-se consistentemente relacionada com o nível de AF. O teste de coordenação olho-mão e o teste de agilidade são os que definem mais precisamente uma tendência regular de alto nivel de atividade física. Programas voltados para aumentar a coordenação segmentar e agilidade devem ser incentivados desde tenra idade nas escolas.

Palavras-chave: competência motora, atividade física, adolescentes, saúde pública.

Resumen—"Relación entre la coordinación segmentaria, la agilidad y la actividad física en adolescentes." La competencia motora (CM) podría estar relacionada con el nivel de actividad física (AF) de los jóvenes. En los últimos años, CM ha sido estudiada como un posible determinante del nivel de AF de los niños, sin embargo no ha sido ampliamente estudiada en adolescentes. Para analizar la relación entre la CM y el nivel de AF, fueron evaluados 533 adolescentes (271 hombres y 261 mujeres) del sureste de España. Para registrar la AF semanal fue utilizado el International Physical Activity Questionnaire (IPAQ), y para la CM, cuatro test coordinativos que incluían el test de lanzar y coger, test de coordinación ojo-mano y ojo-pie y un circuito de agilidad. Los datos fueron analizados utilizando un ANOVA y una regresión logística binaria. La CM global está consistentemente relacionada con el nivel de AF. Los test de coordinación ojo-mano y de agilidad definen con más exactitud la tendencia a un nivel alto de AF. Programas para promocionar la AF centrados en la CM deberían ser enfatizados desde edades tempranas hasta la adolescencia.

Palabras claves: competencia motora, actividad física, adolescentes, salud pública

Introduction

Physical activity (PA) level has been related to health benefits in young and adults. In the last few years a large number of studies have analyzed the variables which determined the PA level in children and adolescents (Craggs, Corder, & Griffin, 2011; Guinhouya, Apété, & Hubert, 2010) Among several factors analyzed, recent studies have considered the influence of motor competence in the PA of young people (Hands, 2008; Hands, Larkin, Parker, Straker & Perry, 2009; Lopes, Rodrigues, Maia,

& Malina, 2011; Okely, Booth, & Patterson, 2001; Raudsepp & Pall, 2006; Stodden *et al*., 2008; Rinne, Pasanen, Miilunpalo, & Malkia, 2010).

Motor competence (MC) has been defined as the degree of skilled performance in a wide range of motor tasks as well as the movement coordination and control underlying a particular motor outcome (D'Hondt, Deforche, De Bourdeaudhuij, & Lenoir, 2009).

Low MC has been related with a lower motivation towards PA in youth (Rose, Larkin, & Berger, 1998). Children with high levels of MC are more physically active, physically fit (Castelli & Valley, 2007), and spend less time in sedentary activities (Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006). Further, adolescents with less MC show lower physical self-concept, which could lead them to abandon the PA habit (Mata, 2008; Rigoli, Piek, & Kane, 2012; Skinner, & Piek, 2001).

The relationship between MC and PA was demonstrated in several studies. In children, MC was positively associated with the percentage of time involved in moderate and moderate-to-vigorous PA and inversely related to sedentary activity (Wrotniak *et al*., 2006). In adolescents, the time involved in PA was associated with better performance in fundamental motor skills (Okely *et al*., 2001; Tittlbach *et al*., 2011). In Spanish adolescents have also been found that those with weaker MC had a more sedentary lifestyle and less physical condition (Mata, 2008).

MC plays an important role in the initiation, maintenance, and decline of physical activity. According to the model created by Stodden *et al*. (2008) the perceptions a child has of his or her competence in PA will influence the participation in physical activity throughout the lifespan. They affirm that there are a positive and a negative spiral of PA engagement. Children who participate in sports achieve greater levels of MC during childhood and into adolescence having more likelihood of being active as they move into adulthood. On the contrary, children who have lower MC will demonstrate a lower perceived motor skill competence, resulting in a negative spiral of PA engagement.

The present study analyzes the relationships between MC, measured through agility, throw and catch, eye-hand and eye-foot coordination tests, with the PA level of a sample in the phase of adolescence. It may be hypothesized that those with better MC will have higher PA levels. However there is a lack of studies in the literature establishing relationships between these variables and it has yet to be assessed among Spanish adolescents. The purpose of this study was to examine the association between MC and PA level in Spanish adolescents. This is part of a larger study about physical activity predictors conducted in the Southeast region of Spain.

Methods

Sample

Data were collected from 533 adolescents (males *n*= 272; females *n*= 261), between 14 and 17 years old who voluntarily participated in the study. The sample was selected from several secondary schools of the Southeast region of Spain (Murcia Region). The sampling process was performed following a stratified multistage process, in which the first stage units were the natural regions in which Murcia Region is divided, the second stage were the local villages, the third the primary schools and the last the students. For the selection of the units in the following two steps was used a selection procedure with probability proportional to size, which results in a self-weighted sample simplifying further analysis. The final selection of the sample was randomized made among the students in the school classrooms, each student in every classroom was offered to participate (they voluntarily accept their participation in the study). For a confidence level of 95% *P=Q*, and alleged error that affects our estimates of ±3.2%.

Measures

Segmental coordination, agility and PA level was measured in the adolescents. Previously, parents and participants gave their informed consent. The results of participants with any diagnosed physical or mental disability were excluded from the data. This study was approved by the ethics committee of the University of Murcia.

To determine the PA level was used the short form of the International Physical Activity Questionnaire (Craig *et al*., 2003). The short version was chosen as it has been validated and used in other studies (Papathanasiou *et al*., 2010; Ramírez-Lechuga, Femia, Sánchez-Muñoz, & Zabala, 2011) and provided us an effective way to measure PA in a wide sample without interrupting in excess the classroom schedule. In the questionnaire the adolescents registered the amount of PA done in the last 7 days. Then, it was converted to metabolic equivalents (MET) which are defined as the ratio of the associated metabolic rate for a specific activity divided by the resting metabolic rate (Ainsworth *et al*., 2001). The resting metabolic rate is approximately 1 MET and reflects the energy cost of sitting quietly. Multiples of 1 MET for a specific activity signify higher energy costs. A formula was implemented to obtain MET-min per week: MET level x minutes of activity x events per week. The compendium of physical activities was used to know the METs intensities (Ainsworth *et al*., 2001). According to their results, the adolescents were classified in one of the three groups:

- High PA: subjects who achieved one of the 2 criteria:
- Vigorous-intensity activity on at least 3 days and accumulating at least 1500 MET-minutes/week.
- 7 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum of at least 3000 MET-minutes/week.
- Moderate PA: subjects who achieved one of the 3 criteria:
- 3 or more days of vigorous activity of at least 20 minutes per day.
- 5 or more days of moderate-intensity activity or walking of at least 30 minutes per day.
- 5 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum of at least 600 MET-min/week.
- Low PA: this is the lowest level of physical activity. Those individuals who do not meet criteria for categories 2 or 3 are considered low/inactive.

To assess the MC the following tests were randomly performed: eye-hand coordination and eye-foot coordination test, agility circuit and throw and catch test. Each participant performed all the tests in a single assessment session. Each test was performed twice, using the best result for data analysis. Between each trial, there was 2 minutes rest. Between every test there was a 5 minutes rest. All the test were performed with the same volleyball ball (65-67 inches in circumference and weighing 260-280 g) except the agility circuit which did not need any ball to perform it.

The scores were collected in a record sheet by two trained researchers. Once obtained the data, a mean of their scores in the 4 coordinative tests was calculated. It was established an average scaled from 0 to 10 points with reference to the values of the percentiles in which participants were placed according to their scores, therefore the maximum score was assigned a value of 10 and the minimum a value of 0. The scoring process of each test is described below.

The 4 coordinative test were specifically constructed for the study. The criteria to construct the test were that they had to evaluate agility, eye-hand and eye-foot coordination through tasks involving the main sporting disciplines that adolescents can practice. The absence of validated test for measuring these skills in adolescents was the reason to construct the test.

Prior to evaluate the MC, the reliability and validity of each test was assessed. All the tests had reliability coefficients *R* intraclass between .96 and .99 for intra-explorer measures and .75 and .86 for inter-explorer measures. Similarly, validity were positive inter and intra-explorer in the four tests, being a great variability between the records, no significant differences were found in the intra-case measures. The validity was established considering the variability in the three measurements made by the two explorers in a predetermined double-blind design.

Agility circuit

Agility is the ability to move quickly and change direction while maintaining control and balance resulting in a combination of speed, balance, power and coordination (Ortega, Ruiz, Castillo, & Sjostrom, 2008).

The circuit was established using 6 cones with a vertical bar fixed inside and two of them with a horizontal bar crossing two cones making a fence. The two fences were set facing each other at a distance of 6 meters. Two cones with vertical bar fixed were set in the middle of the circuit with a separation distance of 4 meters (Figure 3). The participant placed behind the first fence was asked to performance the route as fast as possible. Once passed the goal-line the stopwatch was stopped to obtain a measure in seconds. If any participant touched or threw some cones the test were automatically started over from the beginning being stopped the stopwatch and set again to start. The circuit was done as many times as it was necessary until doing it properly.

The direct scores obtained in this test were classified assigning punctuation from 0 to 10 according to the registers in deciles. The scores were specifically assigned separating by sex and age. The measurement of this test is made through time spent to complete the circuit (seconds). Therefore, the deciles punctuations were inverted in order to get a continuous classification in a scale from 0 (the lowest possible level) to 10 (the highest level).

Eye-hand and eye-foot coordination test

There was set a circuit composed of 6 cones, which had a vertical bar fixed inside, established along a distance of 10 meters (Figure 1). There was a 2 meters distance between cones. The participant stood behind the line to the right of the first cone with the ball in his hands. When the researcher gave the signal and switched on the stopwatch, the test started and the subject had to complete the circuit as fast as possible moving forward from one side to another side avoiding the cones dribbling the ball with their hands (for the eye-hand coordination test) or feet (for the eye-foot coordination test). Once overcome the last cone, the stopwatch stopped and the measurement was registered. If any participant touched or threw some cones, the test were automatically started over from the beginning being stopped the stopwatch and set again to start. The circuit was done as many times as it was necessary until doing it properly.

The measurement followed the same process that in the agility test. The scoring of these tests is made through time spent to complete the circuit (seconds) and then inverted and translated to deciles in a scale from 0 to 10, as explained before.

Throw and catch test

The participant was placed behind a line separated by 1.50 meters from the wall (Figure 2). The test consisted of throwing the ball using both hands as many times as possible. The throwings was performed from the chest to the wall trying to touch inside of a 40 centimeters radious circle drawn on the wall, whose center was located at 1.60 meters from the ground. It accounted for the number of contacts the ball hit inside the circle in a time of 30 seconds. It was not valid if the ball did not fully contact inside the circle.

Figure 1. Agility task.

Figure 2. Eye-hand and eye-foot coordination test.

The measurement of this test is made by counting the number of correct throwings of each participant. Therefore, the deciles were directly registered and classified in a scale from 0 (the lowest possible level) to 10 (the highest level).

Statistical analyses

To analyze data was used descriptive statistics, in the case of categorical variables, relative and absolute frequencies by gender and age while for the continuous variables we calculated the mean, median and standard deviation.

The relationship between categorical variables were analyzed using contingency tables and the c^2 Pearson's product with the corresponding residue analysis. To determine if there were differences in scores depending on the level of MC and PA (IPAQ) was performed an analysis of variance (ANOVA). If differences were significant ($p < .05$) for the main effect of the ANOVA it was made a pairs comparison (*post-hoc*) by the Bonferroni test. Levene test for homogeneity of variance determined that there were no significant differences in the variances of the variables

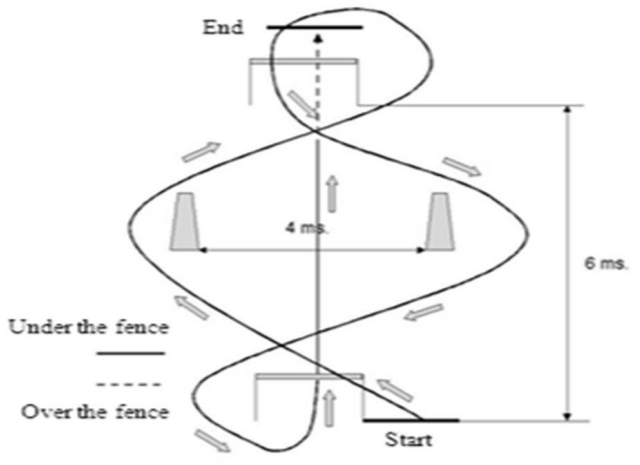

Figure 3. Throw and catch test.

related. In addition, it was conducted a binary logistic regression test to determine the differential prediction of the PA practice habit depending on each coordination test. The dummy variable was the PA level; we allocated the 0 value to low PA level and the 1 value to moderate and high PA level. A 95% probability was established for determining statistical significance. To perform statistical tests was used SPSS version 18.0 software.

Results

Out of all the adolescents, 136 (25.5%) registered high PA level, while 267 (50.1%) moderate and 130 (24.4%) low. The moderate and high PA was significantly associated with males ($p < .05$). Furthermore, out of the 130 participants with low PA, 58 (44.6%) were males and 72 (55.4%) females.

The ANOVA showed that adolescents of both genders who performed high PA reached significantly higher values in the average of the coordination tests ($p < .001$) than those who did not practice PA.

The analysis shows how the MC increases when the PA level is elevated, reaching differences of 4 points among females (Table 3) and nearly 3 points among males (Table 2).

In both genders, the agility ($Exp\ \beta = 1.613$, $\beta = 0.478$) and eye -hand coordination ($Exp\ \beta = 2.158$, $\beta = 0.769$) were the variables which were more strongly related to the PA level (Table 4). The throw and catch test also showed a strong relationship with PA.

Discussion

The purpose of this study was to analyze the association between segmental coordination, agility and the PA level in adolescents. A low percentage of the sample practice regular PA, especially women. The MC, obtained from the total average of the segmental coordination and agility test, showed a relationship with the PA levels, obtaining higher MC scores the most active adolescents.

An important finding was that the results of the hand-eye coordination test and agility test were strongly associated with the level of PA. The agility test includes conditional and coordinative capabilities, being the most related to the youth physical condition coordinative test. Thus, activities involving agility should be included in programs to promote the PA practice in youth (Ortega *et al*., 2008).

Table 1. PA level divided by gender.

			Gender	
			Male	**Female**
PA Level	Low PA	Number	58	72
		% of the PA Level	44.6%	55.4%
	Moderate PA	Number	147	120
		% of the PA Level	55.1%	44.9%
	High PA	Number	67	69
		% of the PA Level	49.3%	50.7%

$\chi^2 = 4'042$; $p < .05$

Table 2. ANOVA relating the males' PA level with the MC.

Males							
PA Level	**MC test Mean**	***N***	**Post-hoc differences**		***p*-value**	***F***	***p*- value**
Low	4.25	58	Low-Moderate Low –High	-.86 -2.94	.000 .000	84.58	< .001
Moderate	5.11	147	Moderate - Low Moderate - High	.86 -2.08	.000 .000		
High	7.19	67	High - Low High - Moderate	2.94 2.08	.000 .000		

PA= Physical activity; MC= Motor competence; *N*= Subjects frequency; *F*= *F* of Snedecor
p-value= Probability. It analyzes the relationship between PA level and MC level.

Table 3. ANOVA relating the females' PA level with the MC.

Females							
PA Level	**MC Mean**	***N***	***post-hoc* differences**		***p*-value**	***F***	***p*- value**
Low	3.42	72	Low-Moderate Low -High	-2.21 -3.85	.000 .000	159.39	< .001
Moderate	5.63	120	Moderate - Low Moderate - High	2.21 -1.64	.000 .000		
High	7.27	69	High - Low High - Moderate	3.85 1.64	.000 .000		

PA= Physical activity; MC= Motor competence; *N*= Subjects frequency; *F*= *F* of Snedecor;
p-value= Probability. It analyzes the relationship between PA level and MC level.

Table 4. Binary logistic regression relating the variables corresponding to the MC test with PA level.

		B	E.T.	Wald	*df*	Sig.	Exp(B)
a	Eye-hand coordination	.769	.121	40.430	1	.000	2.158
	Eye-foot coordination	.098	.034	8.298	1	.004	1.103
	Throw and Catch	.262	.029	80.762	1	.000	1.299
	Agility test	.478	.145	10.937	1	.001	1.613

B: Beta; ET: standard error; Wald: Wald coefficient; *df*: degrees of freedom; Sig: Significance; Exp (B): Exponential of Beta.

The proportion of adolescents having an active lifestyle decreases over the adolescence period (CDC, 2013). In our study the adolescent's PA level decreased linearly with age. The lack of MC may be one of the influencing factors causing that tendency.

In a study with Portuguese children, those with low initial MC considerably decline in PA level during the period of three years, followed by those with medium level of MC. While the participants with a high level of MC maintained stable levels of PA during the follow up time. The final results showed that MC was one of the predictors of PA in children (Lopes *et al*., 2011). A study conducted with a sample of Australian adolescents indicates that those with higher MC, employed more time in organized physical activities, being this relationship stronger in females (Okely *et al*., 2001). In another study with Yorkers children, MC was positively associated with time spent in moderate-intensity and moderate to vigorous activities (Wrotniak *et al*., 2006).

Following the studies mentioned, the relationship found in this investigation may support the theory that having higher MC positively impacts on the adolescents' PA level. Lopes *et al*. (2011) affirm that limited MC may lead to unpleasant experiences in movement activities while better MC is associated with more favorable experiences which encourage involvement in PA. It may be a reason to support our findings.

Stodden *et al*. (2008), created a model explaining how the child' perception of his MC will influence the participation in physical activity throughout the lifespan. The authors affirm that participation in sports and motor activities from the early childhood plays a key role in the young' perception of his MC and those with better perception are more likely to get involved in PA. They named that effect as the positive spiral of PA engagement. Thus, another possible explanation to our findings is that the participants with high MC and consequently increased PA level may have developed their fundamental motor skills through their childhood reaching an optimized MC once in the adolescence, which leads them to the PA practice.

Another relationship was found between the throw and catch test and the PA practice. However, in a study with primary school children, overhand throwing and jump capacity were not significantly related to the PA level in children (Raudsepp, & Pall, 2006). It might be due to the different test implemented in our study. Our throw and catch test required of a high level of eye-hand coordination as well as endurance and strength. Adolescents who obtained better punctuation in that test are those with better overall MC and it has been linked to the maintenance of PA practice (Stodden *et al*., 2008).

This study has several limitations. Firstly, we had to follow the schools timetable to conduct the study with certain availability limits. That was the main reason to select the short form of the IPAQ despite the fact that it may overestimate the adolescents' PA (Lee, Macfarlane, Lam, & Stewart, 2011). Secondly, our bivariated regression model relates PA with MC without considering others variables that may influence the reasons to have a determined level of PA. Our study has cross-sectional design and is unpretentious to establish a casual relationship between the variables; we wanted to intuitively know the relationship between MC and PA level as a pilot process for a future study linking all the PA level predictors in a structural equation model.

The lack of studies about adolescents' motor coordination and PA in the literature did not give us a wide background to base our study. Hence, we studied the main features of adolescents' MC and selected the four test of the study resulting in reliable and appropriate for our requirements. However, there are some others limiting factors related to anatomical and physiological conditions that may have influenced the adolescents' motor performance. Nevertheless, this study is based on a large sample and provided us an overall MC information to contrast with the PA level through comprehensive statistical analysis.

Our study suggests that segmental coordination and agility as members of the overall MC are associated with the PA level in adolescents. Thus, coordination problems can be a barrier to the PA practice in adolescence (Gómez, Ruiz, & Mata, 2006). Considering that the PA level during that period has been described as a predictor of the PA level in the adulthood (Rinne *et al*. 2010), adequate programs for the promotion of organized PA considering the influence of motor coordination, should be encouraged from early ages to the adolescence.

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Authors' note

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