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## **ADOLESCENCE, MOTOR COORDINATION PROBLEMS AND COMPETENCE**

**(ADOLESCENCIA, PROBLEMAS DE COORDINACIÓN MOTRIZ Y COMPETENCIA)**

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### **ABSTRACT**

This paper presents a review of the research focusing on the study of co-ordination and motor competence in the adolescent stage. The purpose of this article was to provide an insight into the different dimensions of adolescent motor development in the influence of the evolution of motor co-ordination at this stage of life. The review included the most relevant studies between 2000 and 2012. Inclusion criteria focused on the selection of studies that have examined adolescents aged between 13 and 17 years, corresponding to the stage of secondary school and the first year of Non-compulsory Education. Also, samples of the studies included participants who do not have physical or intellectual disabilities. The results showed an increased interest in the study of motor co-ordination and show alarming data on increased motor co-ordination problems in this critical stage of life. The authors suggest the need to maintain adequate levels of motor competence in these ages, reflecting on how the low competence may affect other dimensions of adolescent development.

## KEY WORDS

Motor development; psychomotor skills; adolescence; assessment; co-ordination problems.

## RESUMEN

El artículo presenta una revisión de las investigaciones centradas en el estudio de la coordinación y competencia motriz en la etapa adolescente. El objetivo del artículo fue proporcionar una visión sobre las distintas dimensiones del desarrollo motor adolescente en su influencia con la evolución de la coordinación motriz en esta etapa de la vida. La revisión incluyó los estudios más relevantes entre 2000 y 2012. Los criterios de inclusión se centraron en la selección de estudios que han analizado adolescentes de edades comprendidas entre los 13 y 17 años, correspondiendo a la etapa de Educación Secundaria Obligatoria y primer curso de Educación No Obligatoria. Asimismo, las muestras de los estudios incluidos engloban participantes que no presentan discapacidad física e intelectual. Los resultados revelan un aumento del interés por el estudio de la coordinación motriz y muestran datos alarmantes sobre el aumento de los problemas de coordinación motriz en esta etapa tan crítica de la vida. Los autores sugieren la necesidad de mantener los niveles de competencia motriz adecuados en estas edades, reflexionando cómo la baja competencia puede afectar a otras dimensiones del desarrollo de los adolescentes.

## PALABRAS CLAVE

Desarrollo motor; habilidades psicomotoras; adolescencia; evaluación; problemas de coordinación.

## INTRODUCTION

Although many authors have dealt extensively with general human motor development from birth to adulthood (Espenschade, & Eckert, 1980; Ruiz, Navarro, Gutiérrez, Graupera, & Linaza, 2001; Haywood, & Getchell, 2009; Gallahue, Ozmun, & Goodway, 2011), few have produced papers, articles and documents dealing specifically with motor co-ordination during adolescence (Okely, Booth, & Patterson, 2001; Reed & Metzger, 2004).

Adolescence is usually seen as a transitional period towards adulthood. The adolescent undergoes dramatic changes in all dimensions of his/her life. At this stage of development there are not only bodily changes, but there is also a significant improvement in motor competence, both in quality and

quantity (Zaichkowsky, & Larson, 1995; Jürimäe, & Jürimäe, 2000). Different scientific surveys confirm the alarming increase in motor co-ordination problems among teenagers and adolescents (Cantell, Crawford, & Doyle-Baker, 1994; Gómez, 2004; Ruiz, & Graupera, 2003; Sudgen, & Chambers, 2005). These problems have disturbing effects on other dimensions of the adolescent behavior (Skinner, & Piek, 2001). In spite of this, there does not seem to be much concern about the matter in the educational community. It is the aim of this article to analyze this issue.

First, we analyzed relationships of motor co-ordination with psychosocial parameters such as perceived physical competence, levels of self-esteem and social interaction (Skinner, & Piek, 2001; Gómez, 2004; Piek, Baynam, & Barret 2006; Barnett, Morgan, van Beurden, & Beard, 2008), and confirmed the negative impact of co-ordination problems on these parameters. Secondly, we confirmed the existence of links between motor co-ordination and cognitive dimensions, such as academic proficiency (Planinsec, & Pisot, 2006; Ruiz, 1992). Thirdly, adolescents suffering from co-ordination problems show a noticeable reduction in their physical activities and also tend to adopt unhealthy lifestyles (Carney, Hay, Faught, Wade, Corna, & Flours, 2005; Hands, Larkin, Parker, Straker, & Perry, 2009). Fourthly, the relationship between motor co-ordination and the adolescents' physical condition has also been studied.

Adolescents with motor co-ordination problems are less physically fit than students who have no problems. This has a clear effect on the adolescent's health and is directly related to the practice of physical activity. Consequently, the issue should be adequately addressed and evaluated in educational environments (Cantell, Crawford, & Doyle-Baker, 2008; Tsiotra et al., 2006). Finally, motor competence has been related to anthropometric parameters, such as morphological structures, stature, weight, body mass index, fat tissues, muscle perimeters and percentages of fat mass. It is clear that motor co-ordination problems have a negative impact on morphological and functional variables (Visser, Geuze, & Kalverboer, 1998; Davies, & Rose, 2000; Saraiva, & Rodrigues, 2010).

A review of scientific literature dealing with motor co-ordination reveals that most studies have focused on childhood (Rose, Larkin, & Berger, 1997; Ruiz, Mata, & Moreno, 2007; Haga, 2008), whereas adolescence has largely been overlooked. Some authors have labeled the issue a *hidden difficulty* (Gómez, Ruiz, & Mata, 2006) and promoted research aimed at detecting adolescents with such a condition in order to implement the most suitable measures for preventing short, medium and long term effects (Schoemaker, Smits-Engelman, & Jongmans, 2003; Ruiz, 2005).

Most international researchers call motor co-ordination problems *Developmental Coordination Disorder (DCD)* (Geuze, Jongmans, Schoemaker, & Smiths-Engelsman, 2001; López-Ibor, & Valdés, 2002; Visser, 2003). However, for our investigative purposes, we prefer the denomination *Developmental Problems of Motor Coordination (DPMC)* (Ruiz, 2004, 2005; Ruiz et al., 2007). The prevalence of motor co-ordination problems is still unclear. Estimated percentages vary from 6% to 22% of the school population (Ruiz, 2004; Ruiz, & Graupera, 2005). Motor co-ordination problems tend to emerge when the subjects try to perform motor actions, both at gross or fine level, and become clearly apparent in contexts such as Physical Education (PE) classes, when students must put their motor co-ordination to the test. It is therefore in PE classes that it is easiest to detect these problems and take corrective action (Gómez, Ruiz, & Mata, 2006).

This research focuses specifically on adolescence. It is then that teenagers undergo dramatic changes in their physical and psychosocial development, changes which will eventually determine their correct adaptation to the environment (Gómez et al., 2006; Gallahue *et al.*, 2011). In addition, adolescence is the transitional stage from childhood to adulthood, when an impressive array of biological, cognitive and socioemotional changes take place (Santrock, 2005). At this stage, social support and peer acceptance are key developmental issues for teenagers (Skinner, & Piek, 2001).

The main aim of this paper was to review and analyze previously published studies on motor co-ordination and competence of adolescents. The focus of this review was multidisciplinary, since motor co-ordination has been related to other dimensions of adolescents' motor competence.

## **METHOD**

### **Review criteria**

The studies covered in this review of scientific literature deal with adolescents' motor competence and co-ordination. We took the age range between 13 and 17 for the selection of participants. Most of the participants in the study were students correspond to 7<sup>th</sup> and 8<sup>th</sup> grade of middle school and 9<sup>th</sup> to 11<sup>th</sup> grade of high school in the international school system. Another selection criterion was disability. People with intellectual and/or physical disability were excluded. This review covers the most significant contributions on the subject published from 2000 to 2012.

## Selection of primary sources

As primary sources we used the databases PsycINFO, Medline, Pubmed, Educational Resources Information Center (ERIC), E-Journals and SPORT Discus. We also consulted reference manuals to find other publications to reduce the possibility of publication bias or shortage of published information.

## Method selection

The initial search through the databases began with a series of key words targeting more and more closely our specific subject of study. These search terms were then interrelated and cross-referenced to home in on the studies compliant with the predefined selection criteria. The key words used were: *motor competence, motor coordination, motor development and adolescent, motor coordination and adolescent, motor ability and adolescent, assessment motor coordination, motor ability.*

Following the methodological guidelines, the studies under review were arranged into different subcategories according to the dimensions of the adolescent motor development or motor competence they dealt with. The division by subcategories aims not only at facilitating the understanding of our review but also at presenting the studies in chronological order. Studies appear in the form of a summary of their aims, method and conclusions.

## RESULTS

### Motor co-ordination and developmental stages in adolescence

The study of motor co-ordination has focused on the analysis of the growth processes, particularly during adolescence a very sensitive and critical stage of development. Research aims at analyzing how motor co-ordination develops throughout the different stages observed during adolescence (Table 1). This is the case, for example, of Davies and Rose (2000), who dealt extensively with motor development throughout adolescence. Their investigation aimed not only at identifying gender differences and developmental trends, but also at studying motor co-ordination during the different stages of adolescence: pre-puberty, puberty and post-puberty. Participants were 60 American adolescents, 30 male and 30 female. Evaluation tests consisted of 13 motor tasks adapted from the *Bruininks-Oseretsky Test of Motor Proficiency (BOTMP)*, which is a series of exercises of balance, fine motor coordination, throwing and aiming, jumping and running. After the motor test, the *Pubertal Maturation Observational Scale (POMS)* was applied to find the

developmental state of participants, who were then classified according to their scores.

Table 1

*Summary of motor co-ordination and developmental stages in adolescents studies*

<b>Study</b>	<b>Participants</b>	<b>Objective</b>	<b>Instruments</b>	<b>Conclusions</b>
Davies and Rose, 2000	N=60 (7-18 yr)	To identify gender differences across three stages of development: prepubertal, pubertal and postpubertal	BOTMP adaptation. PMOS.	Improved motor performance of boys and girls in adolescence. There is a gradual improvement in childhood. There are gender differences in motor performance.
Ruiz and Graupera, 2003	N=903 (4-14 yr)	To analyse the relationship between gender and motor co-ordination; Cross-cultural study.	M-ABC.	No differences between boys and girls up to 7 and 8 years old. There were differences between different countries
Rodrigues et al., 2007	N=1232 (4.5-16.5 yr)	To assess motor co-ordination of children and teenagers.	Lincoln-Oseretsky Motor Development Scale	Motor performance was significantly lower than chronological age in all age ranges.
Milojevic and Stankovic 2010	N=123 (14-19yr)	To Study longitudinally motor competence.	Battery of 11 tests	Motor performance is continuous and gradual until 18-19 years old.

*M-ABC: Movement Assessment Battery for Children; BOTMP: Bruininks-Oseretsky Test of Motor Proficiency; PMOS: Pubertal Maturation Observational Scale.*

The conclusions drawn can be summarized in three assertions. Firstly, motor performance improves throughout adolescence, both in males and females. Secondly, there are gender differences as far as motor performance is concerned. Finally, At last, results revealed no co-ordination problems during puberty, either in males or females, that is, no evidence was found that co-ordination decreases with the onset of puberty. This study confirms that motor performance improves non-stop throughout adolescence,

and that, if problems arise, the cause would not be a question of a lack of ability but other external factors.

Another interesting research subject has been the possible relationship between gender differences and motor co-ordination. Ruiz and Graupera (2003) studied a large sample of 903 Spanish children and adolescents, aged from 4 to 14 ( $M = 8.65$ ;  $SD = 2.62$ ). The *Movement Assessment Battery for Children* (M-ABC), designed by Henderson and Sugden in 1992, was used to estimate motor co-ordination. This battery is made up of 8 tasks grouped into three dimensions: balance, fine motor co-ordination and gross motor co-ordination, adapted to each particular age range. Results revealed that no differences are observed between boys and girls until they are 7 or 8 years of age, in particular in manual skill tasks, ball skills and balance. These results were later compared with other research conducted in other cultures and countries, such as Japan and the USA. The impact of cultural factors was confirmed, because significant differences emerged in different environments and societies.

In this same line of investigation Rodrigues et al. (2007), published a longitudinal study evaluating the motor co-ordination of Brazilian children and teenagers. The sample was made up of 1232 students aged from 4.5 to 16.5 years old. To evaluate motor co-ordination, the authors applied the Lincoln-Oseretsky Motor Development Scale, adapted by Sloan, which determines the subject's motor age and its relation to the chronological age. The data analysis testified to a developmental progression of motor competences over time, with gender differences caused by biological and environmental factors. To conclude, special mention must be made of the fact that motor age was significantly lower than chronological age across all age ranges. This last conclusion led the authors to encourage parents and educators to think seriously about the importance of correct motor development and how crucial it is to provide suitable opportunities for physical exercise at these ages.

Another longitudinal study was conducted by Milojevic and Stankovic (2010), these researchers used a battery of 11 tests designed to estimate motor abilities. The aim was to study the physical condition and motor competence of a sample of 123 adolescents aged 14-15. Once again, results testify to the continuous and gradual developmental progress of physical and motor skills up to 18-19 years of age.

Lastly, during the last decade it has increased the interest in the relationship between motor competence and the body mass index (BMI), and recent studies are investigating the causes of the rise in obesity and overweight in this stage. Lopes et al. (2012) studying this relationship during childhood and early adolescence. In this study participated 7175 school-

children from Portugal with aged between 6 to 14 years. The tool used to assess motor coordination was the *Körperkoordination test für Kinder* (KKTK test) developed by Kiphard and Schilling (1974) and was also calculated the body mass index (BMI). It was calculated the motor coordination index according to sex and age. The results of this study indicated that motor coordination was related inversely with the BMI. This inverse relationship increased during childhood in both sexes. Overweight participants had poorer motor coordination.

## MOTOR CO-ORDINATION AND PSYCHOSOCIAL FACTORS

Adolescence has not only to do with physical changes. In the transition from childhood to adulthood psychosocial development also takes place. An increasing amount of research is aimed at analyzing possible relationships between motor co-ordination and personality dimensions such as self-esteem, self-perception, anxiety and other social parameters (Table 2).

Table 2

*Summary of Motor co-ordination and psychosocial factors studies*

Study	Participants	Objective	Instruments	Conclusions
Skinner and Piek 2001	N=218 (8-10 yr) (12-14 yr)	To compare and study child and adolescent stage development, with and without DCD.  – Perceived competence and social support.  – Influence on self-esteem and anxiety.	– M-ABC – WISC-III – STAI – SPPC; SPPA – Social Support Scale	DCD Group: lower self-esteem and higher anxiety levels than the control group.  Teenagers were less competent, with lower social support and lower self-esteem than the rest of the group.
Gómez, 2004	N=120 (12-14 yr)	To evaluate motor co-ordination and detect the possible presence of co-ordination problems in an adolescent sample.	– KKTK Test – ECOMI Scale – AMPET Test – Physical Education Questionnaire	Many teenagers were unable to achieve the minimum required by the test norms.  Most were girls



Study	Participants	Objective	Instruments	Conclusions
			<ul style="list-style-type: none"> <li>- GR-SIPPEL</li> <li>- Section 5th of the M-ABC Checklist</li> <li>- Hopelessness Scale for Children</li> </ul>	Relationships were observed between low competition and other psychological and social aspects.
Piek et al., 2006	N=264 (7.5-11 yr) (12-15.5 yr)	To analyse the relationship between fine and gross motor competence and self-perceptions of competence	<ul style="list-style-type: none"> <li>- MAND</li> <li>- SPPC; SPPA</li> </ul>	<p>The types of self perception were directly correlated with the levels of self-esteem and coordination</p> <p>High impact on the level of coordination in the perceived scholastic competence and perceived athletic competence.</p>
Barnett et al., 2008	Year 2000 N=929 (10 yr) Years 2006/07: N=276 (16-17yr)	To study the relationships between children's motor coordination, the practice of physical activities and their physical condition in the adolescent stage.	<ul style="list-style-type: none"> <li>- 8 motor tasks</li> <li>- PSPP</li> <li>- APARQ</li> <li>- Multi- stage Fitness Test</li> </ul>	<p>Motor development is key in the development of positive self-perception in adolescents.</p> <p>Self-perceptions were related to the practice of physical activity and physical cardiorespiratory fitness.</p>

*M-ABC: Movement Assessment Battery for Children; WISC-III: Wechsler Intelligence Scale for Children; STAI: State-trait Anxiety Inventory for children/adults; SPPC: Self-Perception Profile for Children; SPPA: Self-Perception Profile for Adolescent; KKTK: Körperkoordination test für Kinder; ECOMI: Escala de Observación Motriz Infantil; AMPET: Achievement Motivation in Physical Education Test; GR-SIPPEL: Graupera-Ruiz Social preferences for learning in PE Scale; MAND: McCarron: Assessment of Neuromuscular Development; APARQ: Adolescent Physical Activity Recall Questionnaire; PSPP: Physical Self Perception Profile*

In 2001, Skinner and Piek investigated the impact of perceived motor competence on a series of parameters in connection with the personality and social life of Australian students aged from 8 to 14. They studied the motor co-ordination of the subjects and tried to discover the relationship with parameters such as self-esteem, anxiety and social support. The study also compared two age stages, namely childhood (aged 8-10) and adolescence (aged 12-14). The sample was made up of 218 Australian schoolchildren. The authors used *Movement Assessment Battery for Children (M-ABC)* by Henderson and Sugden (1992), the *Wechsler Intelligence Scale (WISC-III, 1991)*, the *State-Trait Anxiety Inventory (STAI)* by Spielberg, (1973 and 1983) designed for children and adolescents, the *Self-Perception Profile for Children and Adolescents (SPPC and SPPA)* by Harter (1985 and 1988) and the *Social Support Scale for older children and adolescents* by Harter and Robinson (1988).

Results revealed that the higher the self-competence, the higher the self-esteem and the lower the anxiety level. Children and adolescents with confirmed signs of DPMC obtained lower self-perception and self-esteem scores than their fellows. Likewise, results also showed that the DPMC group of students saw themselves as less competent than their fellows, not only in sports activities, but also in academic activities, and showed lower levels of social support and more apparent signs of anxiety.

Other studies have concentrated on interaction in PE classes. In Spain, Gómez (2004) conducted the research for her Doctoral Thesis with two main aims: firstly, to evaluate motor co-ordination and detect the possible presence of co-ordination problems in a sample of schoolchildren in ESO (Spanish Secondary Education); secondly, to analyze the psychosocial effects caused by these problems. The sample in this case was made up of 120 Spanish adolescents, aged from 12 to 14 years old ( $M = 12.54$ ;  $SD = .65$ ), all of them in the first year of ESO. The following tests were used: the *Körperkoordination test für Kinder (KTK)*, by Kiphard and Schilling (1974); the *ECOMI, Scale for the Observation of Motor competence in PE Classes*, developed by Ruiz et al. (1997); the *Achievement Motivation in Physical Education Test (AMPET)*, developed by Nishida (1988) and adapted by Ruiz et al. (2004); the *Physical Education Questionnaire* (Carlson, 1995); the *Scale of Social Interaction Preferences in PE Learning (GR-SIPPEL)*, developed by Ruiz et al. (2010); the section 5th of the *Movement Assessment Battery (M-ABC) Checklist*, related to behavioral problems associated with difficulties of movement and adapted by Ruiz et al. (2007); and lastly the *Hopelessness Scale for Children* (Kazdin, Rodgers, & Colbus, 1986), adapted for Physical Education classes.

Results revealed the existence of a large number of adolescents unable to reach the levels of motor competence deemed acceptable for the test standards. The 38.3% of these adolescents had severe problems. It is striking that 83.3% of the children with this kind of problem were females. A crossed examination of test results revealed the enormous impact of lower motor competence on the psychological and social development of adolescents. The students with low motor competence had a negative and mostly passive attitude towards PE classes, had lower performance ambition and were more likely to be socially rejected and isolated with clear signs of alienation in the gym.

Studies have usually aimed at analyzing the relationship between motor competence, both gross and fine, and the children's perception of their own competence level. For Piek et al. (2006) low competence in the performance of gross or fine motor tasks co-relates with low perception of one's own performance achievements. Their study involved the participation of 265 Australian schoolchildren, 164 children (aged 7.5 to 11;  $M = 9.10$ ;  $SD = .81$ ), and 101 adolescents (aged 12-15.5;  $M = 13.84$ ;  $SD = 1.12$ ). The tests used were the *McCarron Assessment of Neuromuscular Development* (MAND) test, designed by McCarron (1982) for the evaluation of gross and fine motor co-ordination, and the SPPC, together with the version adapted for adolescents, the SPPA developed by Harter (1985 and 1988, respectively). These latter estimate the levels of self-esteem and perceived competence in 5 dimensions. The group of children with co-ordination problems obtained lower scores than the control group in the performance of both gross and fine motor tasks. Likewise, the group with motor problems had low scores in their perceived academic proficiency tests, corresponding to their low scores in the performance of fine motor coordination tasks.

On the other hand, as compared with the adolescent group, the younger group obtained higher scores in the tests of perceived academic proficiency and perceived athletic competence, with higher scores in the performance of fine motor coordination tasks. Boys got higher scores in global motor co-ordination exercises. For these authors perceived athletic and academic competence played a key role in the level of self-esteem and was highly dependent on the level of motor competence. They also found significant differences between boys and girls. To sum up, this study showed that there is a relationship between low levels of self-perceived performance and co-ordination problems in groups with motor difficulties, either children or adolescents.

In summary, researchers are increasingly concerned nowadays with the increase in the sedentary lifestyle and obesity levels among schoolchildren. The research in this field analyses the relationships and interactions

between psychosocial factors and the levels of physical condition and physical activity.

Barnett et al. (2008) conducted research on motor co-ordination in children and the subsequent practice of physical activities and their physical condition as adolescents. They also tried to see if there was any relation between these parameters and their self-perception of sports competence. The results of the study were obtained at two different times: in 2000 the motor co-ordination of 929 Australian children, with an average age of 10.1 was evaluated as part of a program to promote physical activity in schools. In the school year 2006/07 the participants were again monitored to estimate how they perceived their sports competence, what levels of physical activity they had and their cardiorespiratory fitness, as an expression of their physical condition. At that moment, only 276 adolescents took part. Motor co-ordination was estimated using the performance scores obtained in 8 motor tasks. The levels of physical activity were measured by means of the *Adolescent Physical Activity Recall Questionnaire* (APARQ), developed by Booth et al. (2002); cardiorespiratory fitness was estimated by means of two standard resistance tests, the bleep test and the PACER test. At last, perceived sports competence was estimated by means of the Self-Perception Profile by Harter.

The analysis of the results revealed that motor competence played a crucial role in the development of positive sports self-perception in adolescents. Self-perception was, in turn, directly related to an increase in the practice of physical activity and physical cardiorespiratory fitness. This study is particularly valuable for its longitudinal approach, the large size of the sample and the relationship between the different dimensions of motor development.

### **Motor co-ordination, physical activity and physical condition in adolescents**

In this age of sedentary lifestyles and high levels of obesity, two of the dimensions of most interest to specialists are the regular practice of physical activity and the physical fitness of children and adolescents, since both parameters are closely related to personal lifestyle and health. There are many studies highlighting the relationships between motor co-ordination and levels of physical fitness and physical activity (Table 3). Carney et al. (2005) conducted a cross-sectional study to correlate co-ordination problems with decreasing levels in the practice of physical activity and find out the possible impact on self-efficacy records. Their study covered 590 Canadian school-children in 4<sup>th</sup> to 8<sup>th</sup> grade. The authors applied the abridged version of the

Bruininks-Oseretsky test of motor proficiency (BOTMP) for the evaluation of motor co-ordination. The perception of self-efficacy in the practice of physical activity was estimated by means of the *Children's Self-Perceptions of Adequacy in and Predilection for Physical Activity* scale (CSAPPA; Hay, 1992). Levels of physical activity were measured by means of a questionnaire on participation in scheduled and non-scheduled sports activities. The conclusion was clear: there was a close relationship between developmental problems of motor co-ordination and low records in the practice of physical activities. Low levels in the practice of physical activities also correlated with low self-efficacy perception among the schoolchildren who took part.

In this same line of research Tsiotra et al. (2006) analyzed the correlation between low motor competence records, physical fitness and the practice of physical activities. The study aimed at putting all these parameters into relation with the different lifestyles of Canadian and Greek boys in early adolescence. Participants were 329 Greek ( $M = 11.46$ ) and 591 Canadian boys ( $M = 11.3$ ). The authors used a bioelectrical impedance scale for the anthropometric values and the abridged version of the BOTMP for motor evaluation. This latter is made up of 14 items and evaluates the performance of gross motor tasks and classifies the subjects according to their scores. The physical condition of the participants was also estimated by means of a shuttle run test. Results showed that Greek pupils had higher percentages of fat mass and lower levels of physical fitness and motor competence than Canadian pupils. The group of Greek pupils also showed higher prevalence of obesity and lower levels of physical fitness and a higher percentage of DPMC than the Canadian ones. The data on the lifestyles of both groups indicated that Greek pupils were less active than Canadian ones, in accordance with their levels of physical fitness and motor competence.

Cantell et al. (2008) conducted another study aimed at correlating developmental problems of motor co-ordination with the health of the participants by age. A sample of 110 Canadian participants was divided into three age groups: children (aged 8-9), adolescents (aged 17-18), and adults (aged 20-60). A variety of tests were used. Firstly, a questionnaire on daily motor competence specifically customized for each age group (Wilson et al., 2000), and another version for both adolescents and adults specially adapted by the authors. Secondly, in order to detect participants with motor co-ordination problems, the authors followed the guidelines in the DSM-IV (APA, 1994). The M-ABC battery was applied in its original version for children, whereas for adolescents and adults use was made of a new version of the M-ABC battery, namely M-ABC-2 (Henderson et al., 2007). To rule out possible intellectual problems, participants were examined by means of intelligence tests for children and adolescents, WISC-III and WAIS-R, respectively (Wechsler, 1991, 1997). To estimate their physical fitness, participants underwent a se-

ries of physical tests and physiological parameters such as blood pressure, body composition, adiposity and bone mineral density were measured.

Results revealed that participants with co-ordination problems had lower levels of physical fitness and health than participants with greater motor competence levels. These results coincide with other studies that also confirm that motor competence and motor co-ordination play a very significant role in the levels of physical fitness and in the practice of physical activity. There is no doubt that good motor competence and motor co-ordination contribute significantly to good general health (Cairney et al., 2005). Participants with low motor competence scores obtained poor results in terms of physical fitness and metabolic indexes. Consequently, the study highlighted the possible risks that co-ordination problems may pose for the development of cardiorespiratory disorders, obesity and abnormal bone density rates.

In this same line of research, Hands et al. (2009) in a longitudinal study correlated motor competence with physical fitness, the practice of physical activity and the lifestyle of a sample of 1,585 Australian adolescents ( $M = 14.06$ ;  $SD = .2$ ). Physical activity was measured with pedometers and physical fitness by means of a battery of tests of flexibility, resistance, strength and body composition parameters (ACHPER: *Australian Fitness Education Award*). Motor competence was estimated by means of the MAND test mentioned above, which has 5 fine motor coordination tasks and 5 gross motor coordination tasks. The results of this study are similar to those of the other studies discussed above: adolescents (boys and girls) with low motor competence scores and co-ordination problems have lifestyles, which are more likely to cause health risks (Kantomaa et al., 2011).

### **Motor co-ordination and cognitive competence**

Cognitive issues have also been dealt with extensively in studies of motor co-ordination (Ruiz, 1992; Ruiz, Palomo, Ramón, Ruiz, & Navia, 2014; Mora, 1997) with varying results. Right from the very beginning, researchers were interested in analyzing the possible relationship between intelligence, motor performance and academic success (Ismail & Gruber, 1967; Cratty, 1972). Different studies measured first the intelligence quotient of participants to rule out any previous bias in this dimension, which could have a possible impact on their motor competence (Skinner & Piek, 2001; Cantell et al., 2008). The study by Planinsec and Pisot (2006) is a good example (Table 3). By first determining the motor co-ordination scores of students with intelligence quotients above and below the average IQ of the group under study, they tried to find out which motor competences, if any,

showed significant differences. The study involved the participation of 550 Slovenian boys with an average age of 13 ( $M = 13.1$ ;  $SD = .87$ ). The authors used a battery of 8 motor co-ordination tests to estimate motor competence: movement co-ordination with the aid of a rhythmic device, hand-eye co-ordination and visual-motor and bimanual co-ordination, general dynamic co-ordination and complex motor co-ordination. To estimate the level of intelligence, the study used the TN20 Intelligence Test (Pogacnik, 1994) made up of 45 progressively more difficult tasks. Results revealed that the best-coordinated adolescents had average intelligence scores within the group, whereas students with the lowest scores in the co-ordination tests had below average intelligence scores.

Table 3

*Summary of Motor co-ordination, physical activity, physical condition and cognitive competence in adolescent's studies*

Study	Participants	Objective	Instruments	Conclusions
Carney et al., 2005	N=590 (9-14 yr)	To analyse the relationships between DCD with practice and self-efficacy.	BOTMP-SF CSAPPA PQ	Direct relationship between DCD, self-efficacy and practice.
Tsiotra et al., 2006.	N=920 Canadian (10.2-13.2 yr) Greek (10.4-12.2 yr)	To examine whether lifestyle differences between Canadian and Greek children may also be reflected in differences in DPMC prevalence rates.	Bioelectrical impedance. BTOMP-SF Shuttle run	Greek pupils showed higher prevalence of obesity, lower levels of physical fitness and a higher percentage of DPMC than the Canadian pupils.
Can-tell et al., 2008	N=110 (8-9 yr) (17-18 yr) (20-60 yr)	To analyse developmental problems with motor coordination aspects and health in every stage of age	M-ABC; MABC-2  DCDQ; DCDQ-T; DCDQ-A  WISC-III; WAIS-R  DEXA Scan and metabolic indices	Participants with co-ordination problems had lower levels of physical fitness and health than participants with greater motor competence levels.

Study	Participants	Objective	Instruments	Conclusions
Hands et al. 2009	N=1585 (14.06 yr)	To examine the relationship between physical activity, physical fitness and motor competence in adolescents.	Yamax Digiwalker SW200 pedometers ACHPER MAND	Motor competence was related to all measures of physical fitness.  There were significant differences in all measures except motor competence.  Men showed better motor performance levels than women
Plan-insec and Pisot, 2006	N=550 (13 yr)	To investigate the relationships between levels of motor coordination and intelligence in adolescents	Battery of 8 motor coordination tests.  TN20 Intelligence Test	Best coordinative results matched adolescents who were within the average range of intelligence, however the lower motor co-ordination scores corresponded with adolescents who scored below average intelligence.

*BOTMP-SF: Short-form of the Bruininks-Oseretsky Test of Motor Proficiency; CSAPPA: Children's Self-Perceptions of Adequacy in and Predilection for Physical Activity; PQ: Participation Questionnaire; DCDQ: Developmental Coordination Questionnaire for Child; DCDQ-T: Developmental Coordination Questionnaire for Adolescent; DCDQ-A: Developmental Coordination Questionnaire for Adult; M-ABC: Movement Assessment Battery for Children; MABC-2: Movement Assessment Battery of Children. 2nd edition; WISC-III: Wechsler intelligence scale for children; WAIS-R: Wechsler adult intelligence scale; ACHPER: Australian Fitness Education Award; MAND: McCarron Assessment of Neuromuscular Development*



In this line of research Katic and Bala (2012) studied 162 Croatian female schoolchildren divided in two groups: 84 girls aged 10-12 ( $M = 11.26$ ;  $SD = .68$ ) and 78 girls with aged 13-14 ( $M = 13.52$ ;  $SD = .63$ ) with two goals. The first was to identify factors related to cognitive and motor development, and the second aim was to identify the factors that were responsible of the cognitive and motor relationships. In this study researchers used a battery of 11 motor coordination tests, and the Raven SPM. The results showed that cognitive functioning plays an important role in the motor competence of girls aged 10-14. On the one hand in the younger age group, cognitive functioning is related to motor regulation of muscle tone, agility and co-ordination. In the group representing puberty students there were relationships between cognitive functioning and co-ordination (intensity and mobility of the lower limbs), and to a lesser extent, with the coordination of the upper limbs and trunk strength.

To explain these results, it has been suggested that coordinated movements are influenced by a series of cognitive operations, which involve visual or visuospatial processing, working memory and quick problem-solving data processing. It would seem, therefore, that motor co-ordination requires the intervention of cognitive and spatial elements at different levels of information processing. This could be taken as evidence to support Gardner's theory of multiple intelligences, and more specifically, the existence of bodily-kinesthetic intelligence.

## DISCUSSION

The main aim of this paper has been to analyze the relationship between motor co-ordination and the different dimensions of the adolescent development. In the last decade an increasing number of educationalists and psychologists have become interested in knowing more about these relationships. Our review of the studies published in the last years on the subject has led us to the conclusion that it is extremely important for adolescents to maintain adequate levels of motor competence to enable them to interact successfully within their cultural environment. There is no doubt that defective motor competence seriously affects other dimensions of adolescent behavior.

Research has confirmed that motor co-ordination develops gradually from childhood to adolescence in a way that is not free from cultural influences, with variable effects on boys and girls (Davies & Rose, 2000; Ruiz & Graupera, 2003, 2005; Rodrigues et al., 2007). The alarming data provided by the study of Gómez (2004) conducted among Spanish schoolchildren reveal a worrying decrease in the motor competence of Spanish adolescents.

This negative trend has a great impact on other aspects of teenagers' behavior and may lead to an unhealthy lifestyle.

The relationships among developmental problems of motor co-ordination with attention problems, low self-esteem and self-concept, among other emotional problems (Skinner & Piek, 2001; Piek et al., 2006) should make parents, teachers and educators engage in serious reflection on the issue. Most studies rely on the theory of Harter (1987) that maintains that individuals who perceive themselves as motor-competent will continue to participate in physical activity, whereas students with low self-perceived competence will tend to reject anything to do with physical and sports activities, in or outside school.

Research has shown that adolescents with co-ordination problems perceive themselves as having low physical competence as a result of their repeated failures in the practice of motor skills. These adolescents are in serious risk of increasingly limiting their participation in physical activity and of entering a process of learned incompetence (Ruiz, 1995 and 2000). Eventually persistent failure leads to despair and anxiety. On the other hand, research results show that fine motor competence is of crucial importance for successful academic development and social interaction. Likewise, gross motor competence has proved to be a key factor in the acquisition of physical fitness and in participation in physical and sports activities. Finally, co-ordination problems can cause a decrease in academic performance and social interaction, with a negative impact on the self-esteem and the social and emotional life of adolescents (Skinner & Piek, 2001; Piek et al., 2006). When adolescents severely limit their participation in sports and leisure activities their present and future health is negatively affected.

As already explained, motor co-ordination problems can have negative effects on the participation of adolescents in physical activities and, consequently, on their physical fitness, with the ensuing increase in obesity (Carney et al., 2005). For students with these problems it is a vicious circle. They become less and less motivated to take part in physical and sports activities and eventually their health, physical fitness and self-perceived competence deteriorate (Carney et al., 2005; Piek et al., 2006). It is widely accepted that the regular practice of physical activity at a healthy level during adolescence has a favourable impact on a person's health in adulthood (Hallal et al., 2006) and, consequently, it is hard to understand why educational authorities pay so little attention to the results of the research on this subject.

Although the study was proposed as a careful analysis, this article presents some limitations. The introduction of key words in English has

excluded research published in languages in which these terms are not detected. It could also have done a more in-depth reviews of the master thesis that have not been included in the principal database.

Currently, research is showing how intervention programs for the development of motor skills in educational centers are producing improvements in the fundamental skills of children (Logan et al., 2012). The authors of this article propose a focus on the assessment of motor co-ordination in the adolescent stage, and suggest implementing intervention programs for the development of motor skills in schools. Thus, intervention programs would not only be focused on the detection and intervention of motor co-ordination problems but they would also propose to enhance motor skill competence in an integrated adolescent development.

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