# Effect of maturation and extracurricular sports activities on motor coordination. A longitudinal study

## Efecto de la maduración y las actividades deportivas extraescolares sobre la coordinación motriz. Un estudio longitudinal

*José Manuel Cenizo-Benjumea*[1]
*Javier Gálvez-González*[1]
*Jorge Ramírez-Lechuga*[1]
*Soledad Ferreras-Mencía*[2]

[1] Department of Sports and Informatics, Faculty of Sports, Pablo de Olavide University, Spain
[2] University School of Nursing and Physiotherapy, Pontifical University of Comillas, Spain

**Correspondence:**
Jorge Ramírez-Lechuga
jrlechuga@upo.es

**Short title:**
Motor Coordination, Maturation and Extracurricular Sports Activities

**How to cite this article:**
Cenizo-Benjumea, J.M., Gálvez-González, J., Ramírez-Lechuga, J., & Ferreras-Mencía, S. (2024). Effect of maturation and extracurricular sports activities on motor coordination. A longitudinal study. *Cultura, Ciencia y Deporte, 19*(61), 2096. https://doi.org/10.12800/ccd.v19i61.2096

**Received:** 08 August 2023 / **Accepted:** 28 June 2024

## Abstract

The objective of this study was to analyze the behavior of motor coordination during the school period between 6 and 11 years of age and to longitudinally study the effect of participation in extracurricular sports activities and peak height velocity on this variable motor development. A longitudinal descriptive design was used (67 primary school children). Motor coordination was measured using the 3JS test. During the investigation, the subjects regularly participated in extracurricular sports activities. The maturation is reduced by calculating the peak height velocity. The present longitudinal study carried out over six years in boys and girls in Primary Education showed: 1) an increase in the level of motor coordination from 6 to 11 years of age, 2) a different motor coordination behavior between the group of children and girls who performed regular extracurricular sports activities and the group that did not perform these activities, and 3) the predictive value of the level of motor coordination at 6 years of age, regular participation in extracurricular sports activities, and peak height velocity over the degree of motor coordination at age 11.

***Keywords****:* Motor development, schoolchildren, peak height velocity, Primary School.

## Resumen

El objetivo de este estudio fue analizar el comportamiento de la coordinación motriz de forma longitudinal en escolares entre los 6 y 11 años de edad y estudiar el efecto sobre ella de la participación en actividades deportivas extraescolares y el pico de velocidad máxima de crecimiento. Se utilizó un diseño de tipo descriptivo longitudinal (participaron 67 escolares de Educación Primaria de un centro educativo andaluz). La coordinación motriz fue medida a través del test 3JS. Los resultados muestran: 1) un aumento del nivel de coordinación motriz desde los 6 años hasta los 11 años (incremento de 16.08 a 24.03 en niños y de 12.63 a 19.67 en niñas), 2) un comportamiento de la coordinación motriz diferente entre el grupo de niños y niñas que realizaron regularmente actividades deportivas extraescolares y el grupo que no realizó estas actividades y 3) el mejor valor predictivo del nivel de coordinación motriz a los 6 años, la participación regular en actividades deportivas extraescolares y la edad del pico de velocidad máxima de crecimiento sobre el grado de coordinación motriz a los 11 años (β Estandarizado= .463 frente a .348 y -.225 respectivamente). Podemos concluir que la coordinación motriz a los 6 años es el mejor predictor de la misma a los 11.

***Palabras clave****:* Desarrollo motor, enseñanza primaria, tiempo libre, educación física.

## Introduction

Motor development is a process in which multiple variables intervene to enable people to feel competent in overcoming various motor tasks posed to them (Ruiz, 2004). One of these variables is motor coordination (MC), which is an essential trait in the correct development of human motor skills (Chiva-Bartoli & Estevan, 2019) and is decisive in comprehensive development during childhood (Smits-Engelsman et al., 1998). Several factors influence this process. MC improves with age; it is greater in boys than in girls with regard to object control (Cenizo et al., 2019), varies depending on geographical location, and may be lower in urban environments (Torralba et al., 2016). It also depends on culture (Luz et al., 2019) and family characteristics, since older siblings have better MC (Chiva-Bartoli & Estevan, 2019), socioeconomic status (Valdivia et al., 2018), extracurricular sports practices (Ericsson, 2011; González et al., 2009), and growth and maturation (Hills &Byrne, 2010).

MC is one of the most important elements of motor competence and is best related to health (Herlitz et al., 2021; Reyes et al., 2019; Ruiz-Pérez et al., 2015), because it is It is about the ability to order and organize motor actions oriented toward a given objective with precision, efficiency, economy and harmony, which requires the activity of the nervous system that integrates all the motor, sensitive and sensory factors necessary for the adequate performance of tasks movements (Hernández & Velázquez, 2004).

From a global perspective, MC is related to physical and mental health because better MC is related to improved movement control, which leads to a reduction in the number of injuries (Shumway-Cook & Woollacott, 2007), better cognitive and physical development (Diamond, 2000), and improved executive function (Zwicker et al., 2010).

Multiple cross-sectional studies have indicated that participation in extracurricular sports activities (ESA) entails psychological benefits (motivation, positive self-esteem, self-regulation, self-control, and personal satisfaction) (Suárez & Moreno, 2022; Wang et al., 2020), education (Gonzáles & Portalés, 2014), physical condition (Chacón et al., 2020), motor competence (Santos et al., 2013; Skowroński et al., 2019), and health (García & Fernández, 2020; Jiménez-Pavón et al., 2010; Kamba et al., 2014). Therefore, it is important to promote physical sports activities outside school hours (Reverter et al., 2020; Reverter et al., 2014) to benefit schoolchildren. However, other studies have not concluded that extracurricular physical activity is a predictor of significant improvement in motor skills (Chivas & Estevan, 2019).

In the scientific literature, longitudinal studies have shown an inverse relationship between children's weight and future MC level and vice versa (Hondt et al., 2014), and a reciprocal relationship between children's MC and body fat and peak oxygen consumption during seven years of follow-up (6-13 years) (Lima et al., 2019). However, no longitudinal studies have analyzed the effects of ESAs on motor coordination.

In addition to extracurricular activities, the process of maturation and growth is another variable that influences the motor skills of schoolchildren, given the complex interactions between genetic, environmental, and developmental factors (Malina, 2004). These conditions interfere with various skills, including sports and physical exercise (Hills & Byrne, 2010).

Physical growth is a biological process that begins before birth and ends during adolescence (Garrote-Escribano & Villarroel, 2021). During this process, certain periods of faster growth are observed without a constant rhythm (Garrote-Escribano & Villarroel, 2021). During childhood, an increase in the speed of growth is perceived, stabilizing during the next few years and accelerating again in adolescence and puberty when the peak of maximum growth speed (PHV) occurs (Malina & Rogol, 2011).

The study of physical growth allows us to understand the variability in human maturation owing to genetic potential, biological characteristics, and environmental factors (Gómez-Campos et al., 2016). This type of study is essential because motor development progresses as a function of growth, maturation, and learning (Hills & Byrne, 2010).

In growth studies, PHV is considered a somatic indicator of maturation during puberty and adolescence, which indicates the age at which maximum growth occurs during this stage. The proposal by Mirwald et al. (2002), based on simple anthropometric measurements, is a reliable indicator for analyzing the PHV of children and adolescents.

The relationship between maturation and participation in extracurricular sports activities and MC has been investigated in cross-sectional design studies (Chiva & Estevan, 2019; Freitas et al., 2015; González de Mesa et al., 2009), with consequent limitations when establishing a cause-effect relationship. However, it remains unclear to what extent continuous participation in ESA and PHV influences the development of MC, and whether both variables are interconnected or mutually reinforcing (Freitas et al., 2016; Luz et al., 2016).

Therefore, the objective of this study was to longitudinally analyze motor coordination behavior during the school period between 6 and 11 years and to study the effects of a) participation in extracurricular sports activities and the peak of maximum growth speed on motor development.

## Materials and Methods

### *Design*

This was a longitudinal descriptive study with two groups (Bisquerra, 2012). The effects of participating in extracurricular activities and the age of PHV were analyzed in locomotion and object control during the 6-year school period (between 6 and 11 years).

### *Participants*

The final sample consisted of 67 schoolchildren from a Primary Education center, selected using the intentional non-probabilistic sampling method (Bisquerra, 2012). The initial sample comprised 80 students, thirteen of whom left the center or repeated a grade throughout the 6 years that the students attended the Primary Education stage.

The Center's School Council approved the participation in this study. The Helsinki recommendations for research with people were considered for its development. The legal representatives of the schoolchildren were informed by the researchers in detail and in writing of their characteristics and procedures, as well as by signing informed consent.

### *Procedure*

All measurements were carried out during Physical Education class time, always by the same researchers and under similar conditions. The MC evaluation tests were carried out in the educational center facilities for a period of two days in December of each school year.

MC (locomotion and object control) was measured using the 3JS test, which was validated with internal consistency (Cronbach's alpha = .827), temporal stability (correlation coefficient = .99), and inter-observer agreement (correlation coefficient = .95) (Cenizo et al., 2016). The protocol detailed by the authors for its application is as follows (Cenizo et al., 2017). This test evaluates the children's motor development by measuring locomotion and object control in two dimensions. It consists of seven tasks that are performed consecutively, in which participants must perform three vertical jumps on a suspended pike, a longitudinal turn, two throws with one hand above the head, two kicks with the foot at a goal, a race with change of direction, a moving bounce, and driving the ball with the foot. The final obtained value serves as a reference for the motor coordination level.

For the comparison of MC levels, the variable intervals (INT) (Cenizo et al., 2015) were used, which categorizes the MC variable. With this division of sample scores, an absolute measure is achieved that allows assessing the distance of each subject with respect to the average of the age group (Morales, 2011). This categorization is important in the field of motor development, where the level of each subject must be compared with that of the members of the group. The sample was divided by age into five intervals, each of which comprised a standard deviation (except for the two extremes), resulting in five groups of MC levels, where each level was equivalent to the same difference (standard deviation), except for the first and last intervals. The mean was used as a reference, and the difference between the right and half on the left was calculated. This range is defined as interval 3 or normal MC. Next, a reference is calculated on both sides, achieving Intervals 2 (bad MC) and 4 (good MC). Finally, the remaining samples on both sides constitute intervals 1 (very bad MC) and 5 (very good MC).

During the 6 years of the Primary Education stage, the regular participation of the subjects in extracurricular sports activities was recorded with a monitor in schools or sports clubs, comparing the information provided by the legal guardians of the subjects with that provided by the trainers-monitors. for each sports modality (football, basketball, dance, swimming, rhythmic gymnastics, skating, karate, athletics, and boxing). Two groups were formed: one with students who had participated in ESA regularly in at least one sport during the six years of the study (27 boys and 20 girls), and another with students who had not participated in ESA or had not attended regularly (10 boys and 20 girls).

The level of biological maturation was determined using the equation proposed by Mirwald et al. (2002) for December, when all the students were aged 11 years, allowing cross-sectional calculation of the PHV. This procedure involves the interaction between the anthropometric variables of age, weight, height, and head-trunk height to estimate the date on which the subject reaches PHV, which is considered an index of biological maturation, expressed as a function of time (years). This procedure is missing or has elapsed between the chronological age and PHV.

The chronological age was determined using the decimal date of the day of birth and the decimal date of the control day. To determine body mass (kg), the subjects were barefoot with as little clothing as possible, and a Tanita digital scale with a precision of 100 g was used on a scale from 0 to 150 kg. To evaluate the height (cm), a Seca brand aluminum stadiometer was used, graduated in millimeters and with a scale of 0-250 cm. Trunk head height was assessed by placing the subjects on the Frankfurt plane without shoes and using a wooden bench with a firm backrest with a height of 50 cm and a measurement scale of 0-150 cm and with a precision of 1 mm. Two measurements of the Weight, standing height, and head-trunk height were measured.

### *Statistical analysis*

The Friedman test was applied to study significant differences between the measurements of the variable that organizes the levels of MC, called "INT" of the same group of schoolchildren during the six years of primary education (Cenizo et al., 2015). Multiple comparisons were performed using the Wilcoxon rank test because each variable was an ordinal measurement.

For the dependent variable MC, a mixed design factorial analysis of variance was carried out, in which the performance of ESA and sex were between-subjects fixed effects factors, while the time of measurement of the dependent variable was a measurement factor. Six levels were repeated intra-subject because six measurements were carried out, one in each of the years of the Primary Education stage.

To predict the effect of the variables "motor coordination 6 years" (MC6), "extracurricular sports activities" (ESA), and "maturation" on the dependent variable "motor coordination 11 years" (MC11), a multiple regression model was calculated using the stepwise method. Standardized values of the maturation variables were used to allow them to be included in the model. The non-collinearity of the independent variables was also assessed.

SPSS statistics28 software was used for statistical analysis. The significance level was set at 5% for all analyses.

## Results

The PHV range was in boys (mean = -2.07 ± 0.419; maximum = -1.20; minimum = -2.90) and in girls (mean = -0.35 ± 0.50; maximum = 0.70; minimum = -1.30)

Table 1 shows the mean values and standard deviation of the MC of the subjects in each of the six years in which they were evaluated. The mean scores and standard deviation of each of the five INTs were also observed in different years, and differences were identified by sex.

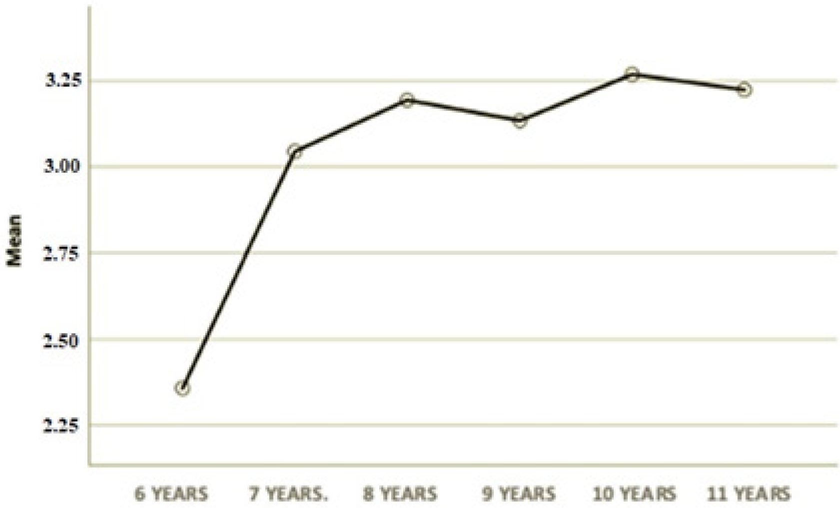
**Table 1**
*Evaluation of motor coordination depending on age, sex and the variable intervals.*
*Data are shown as mean ± standard deviation*

| | | 6 YEARS | 7 YEARS | 8 YEARS | 9 YEARS | 10 YEARS | 11 YEARS |
|---|---|---|---|---|---|---|---|
| MC | Boys (n = 37) | 16.08 ± 2.68 | 19.57 ± 2.35 | 21.35 ± 2.84 | 22.19 ± 2.90 | 23.03 ± 2.71 | 24.03 ± 2.53 |
| | Girls (n = 30) | 12.63 ± 2.31 | 16.13 ± 1.71 | 17.80 ± 2.04 | 18.17 ± 1.78 | 19.27 ± 1.59 | 19.67 ± 1.80 |
| INT 1 | Boys | (n = 5)<br>12.00 ± 0.00 | (n = 0) | (n = 0) | (n = 0) | (n = 1)<br>17.00 ± 0.00 | (n = 0) |
| | Girls | (n = 5)<br>9.40 ± 0.89 | (n = 3)<br>12.67 ± 0.57 | (n = 0) | (n = 1)<br>14.00 ± 0.00 | (n = 0) | (n = 0) |
| INT 2 | Boys | (n = 13)<br>14.38 ± 1.26 | (n = 6)<br>16.33 ± 1.21 | (n = 7)<br>17.57 ± 0.53 | (n = 8)<br>18.25 ± 0.85 | (n = 1)<br>19.14 ± 0.90 | (n = 5)<br>19.20 ± 1.30 |
| | Girls | (n = 16)<br>12.00 ± 0.73 | (n = 6)<br>14.83 ± 0.40 | (n = 7)<br>15.14 ± 1.06 | (n = 4)<br>15.75 ± 0.50 | (n = 4)<br>16.75 ± 0.50 | (n = 4)<br>17.00 ± 0.00 |
| INT 3 | Boys | (n = 15)<br>17.87 ± 0.83 | (n = 18)<br>18.78 ± 0.80 | (n = 17)<br>20.53 ± 1.37 | (n = 12)<br>21.00 ± 0.85 | (n = 12)<br>22.64 ± 9.29 | (n = 13)<br>23.00 ± 0.70 |
| | Girls | (n = 7)<br>15.14 ± 0.69 | (n = 14)<br>16.36 ± 0.49 | (n = 13)<br>17.54 ± 0.51 | (n = 20)<br>18.20 ± 0.83 | (n = 20)<br>18.30 ± 0.48 | (n = 22)<br>19.54 ± 1.14 |
| INT 4 | Boys | (n = 4)<br>20.00 ± 0.00 | (n = 12)<br>21.92 ± 0.99 | (n = 10)<br>23.90 ± .87 | (n = 16)<br>24.75 ± 1.06 | (n = 16)<br>25.60 ± 0.63 | (n = 18)<br>25.89 ± 7.58 |
| | Girls | (n = 2)<br>17.00 ± 0.00 | (n = 7)<br>18.29 ± 0.48 | (n = 9)<br>19.78 ± 0.97 | (n = 5)<br>20.80 ± 0.83 | (n = 5)<br>20.50 ± 0.89 | (n = 4)<br>22.75 ± 0.50 |
| INT 5 | Boys (n = 0) | (n = 0) | (n = 1)<br>25 ± 0.00 | (n = 3)<br>26.33 ± 0.57 | (n = 1)<br>27.00 ± 0.00 | (n = 0) | (n = 1)<br>28.00 ± 0.00 |
| | Girls (n = 0) | (n = 0) | (n = 0) | (n = 1) | (n = 0) | (n = 0) | (n = 0) |

*Note:* CM: motor coordination; INT: variable intervals (categorization of motor coordination).

The Friedman test, with which the MC INT of the group measured in the six years of primary education studied, showed significant differences ($p < .001$) in the intra-measurements. -subject. Significant differences were observed only between the MC measured at the beginning of 6 years and the MC of the same group measured ($Z = 5.582$, $p < .001$). In subsequent years, the group's MC remained in the same range, without significant changes from 7 to 11 years (Figure 1).

**Figure 1**
*Arithmetic mean of the motor coordination intervals of the same group of schoolchildren throughout the six years of Primary Education*




In the mixed design factorial variance analysis, the Mauchly statistic showed that the assumption of sphericity ($p < .001$) is not met, so the univariate Huynh-Feldt alternative was used for the calculation of the F statistic (Table 2).

The results show significant differences between the MC measures over the six years of Primary Education studied, with a large effect size ($F = 294.02$, $p < .001$, $\eta^2 = .824$).

**Table 2**
*Test of intra-subject effects of the development of motor coordination*

| | Type III sum of squares | Degrees of freedom | Mean square | *F* (Huynh-Feldt) | *Sig.* | *Partial eta squared* | Non-centrality parameter | Observed power |
|---|---|---|---|---|---|---|---|---|
| Year | 2055.358 | 4.045 | 508.184 | 294.016 | .001 | .824 | 1189.153 | 1.000 |
| Year*ESA | 20.622 | 4.045 | 5.099 | 2.950 | .020 | .45 | 11.931 | .790 |
| Year*Sex | 3.396 | 4.045 | 0.840 | 0.486 | .748 | .008 | 1.965 | .166 |
| Year*ESA*Sex | 0.929 | 4.045 | 0.230 | 0.133 | .971 | .002 | 0.538 | .078 |

*Note:* ESA: Extracurricular sports activities.

It is observed that there is a main effect of the "ESA" factor on MC ($F = 2.95$, $p < .05$, $\eta^2 = .45$), whereas sex did not show to have an effect on it ($F = 0.486$, $p = .727$, $\eta^2 = .008$), and neither did the interaction of the factors. The evolution of MC behaves differently only between the group with ESA and the group that does not perform ESA (Figure 2 and Figure 3).

Through stepwise multiple regression, a model was obtained that includes the three variables, "MC6", "ESA" and "maturation" that significantly improved the prediction of the dependent variable "MC11".

The collinearity indices of the independent variables were acceptable (Table 3), and the Durbir-Watson statistic indicated the independence of the residuals (DW = 2.303). Regression analysis revealed the existence of a significant relationship between variables ($F = 35.496$, $p < .001$).

The change in MC at 11 years of age can be explained by the proposed model, which includes the predictor variables of MC at 6 years, RDW, and maturation, with an R2 = .66. Table 2 shows the standardized coefficients and their probability values. The standardized β value shows that the predictive value of the variables is greater in the case of 6-year MC, followed by ESA and finally maturation, which is negatively related; thus, MC is greater as schoolchildren approach the peak of the maximum maturation speed.

**Figure 2**
*Estimated marginal measures of motor coordination development according to participation in extracurricular sports activities during the 6 years of study*

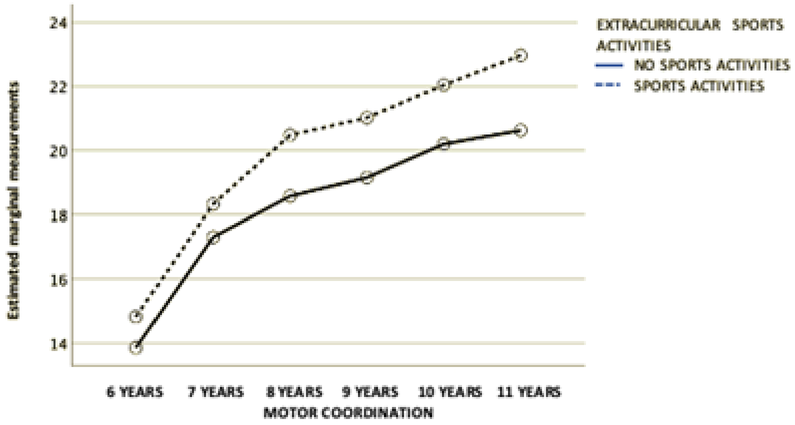



**Figure 3**
*Evolution of motor coordination development according to participation in extracurricular sports activities during the 6 years of study, differentiating by sex*

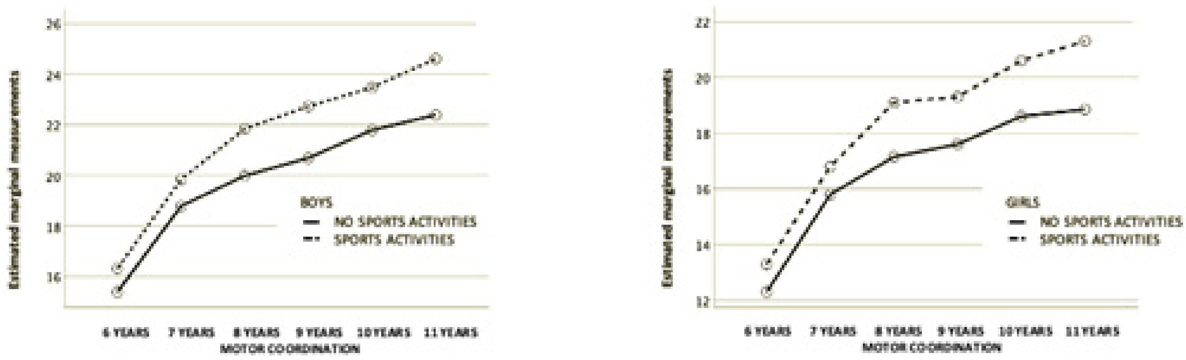



**Table 3**
*Multiple regression analysis (Stepwise)*

| | | | | | Collinearity | |
|---|---|---|---|---|---|---|
| | ***β*** | ***SE β*** | ***β* Standardized** | ***Sig.*** | **Tolerance** | **VIF** |
| **Constant** | 14.006 | 1.381 | | | | |
| **CM6** | 0.471 | 0.096 | .463 | < .001 | .688 | 1.453 |
| **ADE** | 2.152 | 0.528 | .348 | < .001 | .850 | 1.177 |
| **Maturation** | -0.820 | 0.341 | -.225 | .02 | .707 | 1.414 |
| $R^2$ adjusted = .641; Durbin-Watson = 2.303. | | | | | | |

*Note:* ESA: Extracurricular sports activities; CM6: motor coordination at 6 years; VIF: variance inflation factor.

## Discussion

The objective of this study was to analyze the behavior of MC longitudinally during the school period between 6 and 11 years of age, and to analyze the effect of PHV and participation in ESA on this characteristic of motor development.

The results indicate an increase in the MC level between 6 and 11 years, an increase in the INT at 7 years, and the maintenance of the MC level up to 11. Furthermore, a different MC behavior was observed between the group that regularly participated in ESA during the six years and the group that did not engage in ESA during that period. Finally, the results indicate that the level of MC was at 6 years of age, performing ESA every year within the studied age range, and that PHV can predict the degree of MC at age 11.

The results of the present longitudinal study show that MC increases progressively with age, and that it is therefore dependent on the passage of time, coinciding with other previous works, such as the cross-sectional studies by Cenizo et al. (2019) with children aged 6 to 11 years and from Rosa et al. (2020) with samples between 6 and 8 years old, and Valentini et al. (2016) with children from 3 to 10 years old using the TGMD II and Torralba et al. (2016) with children from 7 to 10 years old evaluated through the KTK. Similarly, Biino et al. (2023), in a longitudinal study, found that MC improves with age during the school period, although it is negatively affected by increased weight during puberty.

Analysis of the relationship between MC and sex revealed an upward trend for both sexes throughout the study period. These results are in agreement with those found by Cenizo et al. (2019), in which boys had better values at six years old than girls, but both experienced a similar progression in relative terms each year, and there were no significant differences between them at the assessment moments during the period studied. In this study, improvement in both sexes was greater in the first years; therefore, there is less room for qualitative improvement from the age of 9 to 11 years. In relation to this, Valentini et al. (2016) showed a greater positive evolution of locomotor skills from early childhood to middle childhood, subsequently producing a plateau in the development of these skills.

When we assessed the behavior of the MC by analyzing its categorical evolution in the INT, an increase in this capacity was observed between 6 and 7 years, and maintenance was maintained until 11 years. This corroborates the upward evolution of MC throughout the study period given that it is necessary to increase the MC value throughout life to maintain INT (Cenizo et al., 2015). However, there was an increase in INT within the first two years of life. Some of the reasons that may justify this are that these children began to participate in weekly Physical Education sessions at the age of six years, and the offer and participation in ESA is usually greater from this age onwards. In this regard, it has been shown that participation in school (Latorre et al., 2018) and extracurricular physical activity programs (García-Marín & Fernández-López, 2020) during the early childhood education stage improves various motor variables. This was verified by a cross-sectional study conducted by Delgado-Lobete and Montes-Montes (2017), in which the motor development of boys and girls aged 3–6 years who regularly participated in ESA was significantly higher than that of their peers who did not participate.

Regarding the influence of ESA on the level of MC, it was observed that the subjects who practiced some type of sporting activity during the six years obtained better levels than those who did not participate regularly. These data agree with those of a nine-year longitudinal study conducted by Ericsson (2011), in which the group that received five weekly physical education sessions showed higher MC levels than the group that received two weekly sessions. Similar results were found by González de Mesa et al. (2009), who involved children aged 4 to 14 years. These differences confirm that regular ESA at school age improve motor development.

In relation to the regular practice of ESA, it is important to highlight that in both boys and girls, differences are observed in the level of MC between those who practice ESA and those who do not.

On the other hand, according to the regression model, it was observed that the MC was at six years, the regular practice of ESA during the six years studied, and the PHV predicted the MC level at 11 years.

According to these results, the MC level at six years is of special interest. At this age, the compulsory educational stage begins, and boys and girls face important demands (Mathisen, 2016), where motor development plays a fundamental role in academic success (Herrera-González, 2015). This was demonstrated in different longitudinal studies, in which an optimal motor skill level at age 6 favored motor development during the rest of childhood. Reyes et al. (2019), in a longitudinal study over three years with boys and girls who were initially between 4 and 9 years old, concluded that the strongest and most agile children presented more pronounced trajectories of thick MC with age. Likewise, a seven-year longitudinal study conducted by Lima et al. (2019) found that lower body fat and higher maximal oxygen consumption at 6 years of age were associated with greater motor competence during childhood.

In addition to MC at six years, regular ESA practice during the study period predicted MC at 11 years. This aspect, together with the fact that boys and girls who regularly performed ESA obtained higher MC values, highlights the importance of this type of activity during non-school hours on the motor development of students. In a longitudinal study carried out by Ericsson & Karlsson (2014) over nine years, in the experimental group that received five weekly sessions of Physical Education, only 7% of the subjects showed deficits in their motor skills compared to 47% of the control group who only completed two weekly Physical Education sessions during the same period.

The age of the PHV plays a fundamental role in the prediction of MC at age 11 years. This occurs in the middle of the pubertal period (range: girls, 10-12 years; boys, 12-14 years) (Temboury, 2009). At this moment, great hormonal mobilization is triggered until reaching the state of adult maturity, causing an increase in height and weight, as well as the completion of skeletal growth accompanied by a marked increase in bone mass, changes in body composition (Gómez-Campos et al., 2013; Malina & Rogol, 2011), and increases in physical performance (Carvalho et al., 2011). Growth and maturation as biological processes, along with development, occur simultaneously and interact, and can be influenced by physical activity and can affect activity, performance, and physical condition (Malina, 2014). This is supported by a study by Dalen et al. (2017), who concluded that Norwegian students aged 13 to 16 with a higher level of physical maturity have an advantage in Physical Education and sports. In our study, boys and girls who were close to PHV had better MC values at age 11.

This prediction of the level of MC at age 11 offered by the present study suggests that starting at age 6 with a high level of MC, participating regularly every year in the ESA, and being close to the PHV age significantly favors the level of the MC. Malina (2014) advocated the need to recognize the interaction between biology and behavior (biocultural approach) as a possible influence on motor competence. Hence, based on the results of this study, we support the proposal defended by the authors.

Despite the conclusive data of this study, its limitations make us cautious with its statements, as this study only included students from the same school and in a limited number.

## Conclusion

This longitudinal study carried out over six years in boys and girls in Primary Education found the following: 1) an increase in the level of MC from 6 years to 11 years; 2) different MC behaviors between the group of boys and girls who regularly performed ESA and the group that did not perform these activities; and 3) the predictive value of the level of MC at 6 years, regular participation in ESA, and the age of the PHV on the degree of MC at 11 years.

Therefore, the Early Childhood Education stage should reinforce the motor area, which influences global motor skills, which is a determinant of MC, given that it is the best predictor of MC at the end of the school stage. Given the importance of ESAs in the development of MC, they must be adapted for each age group.

The results of this study provide useful information for physical education teachers and professors to help them individualize the teaching-learning process of their students, considering the level of MC, PHV, and regular practice in ESA.

Future studies should analyze the effects of different types of ESA on MC.

## Ethics Committee Statement

It does not apply because the tests performed were non-invasive.

## Conflict of Interest Statement

There is no conflict of interest. The funding entities or institutions had no influence on the design of the study, the analysis of the data or the interpretation of the results.

## Funding

This research did not receive funding because it was not necessary.

## Authors' Contribution

Conceptualization J.M.C.B., J.G.G., J.R.L., & S.F.M.; Methodology J.M.C.B., J.G.G., J.R.L., & S.F.M.; Software J.M.C.B., J.G.G., J.R.L., & S.F.M.; Validation J.M.C.B., J.G.G., J.R.L., & S.F.M.; Formal Analysis S.F.M.; Investigation J.M.C.B., J.G.G., J.R.L., & S.F.M.; Resources J.M.C.B.; Data Curation J.M.C.B., J.G.G., J.R.L., & S.F.M.; Writing – Original Draft J.M.C.B., J.G.G., J.R.L., & S.F.M.; Writing – Review & Editing J.M.C.B., J.G.G., & J.R.L.; Visualization J.M.C.B., J.G.G., & J.R.L.; Supervision J.M.C.B., J.G.G., & J.R.L.; Project Administration J.M.C.B., J.G.G., J.R.L., & S.F.M. All authors have read and agreed to the published version of the manuscript.

## Data Availability Statement

Data available upon request to the corresponding author (jrlechuga@upo.es).

## References

Biino, V., Pellegrini, B., Zoppirolli, C., Lanza, M., Gilli, F., Giuriato M., & Schena, F. (2023). Gross motor coordination in relation to weight status: a longitudinal study in children and pre-adolescents. *Frontiers in Public Health, 11*, 1242712. https://doi.org/10.3389/fpubh.2023.1242712

Bisquerra, R. (2012). *Metodología de la investigación educativa*. Muralla.

Carvalho, H., Coelho-Silva, M., Goncalves, C., Philippaerts, R., Castagna, C., & Malina, R. (2011). Age-related variation of anaerobic power alter controlling for size and maturation in adolescent basketball players. *Annals of Human Biology, 38*(6), 721-7. https://doi.org/10.3109/03014460.2011.613852

Cenizo-Benjumea, J.M., Ravelo, J., Morilla-Pineda, S., Ramírez-Hurtado, J.M., & Fernández-Truan, J.C. (2016). Design and validation of a tool to assess motor coordination in primary. *Revista Internacional de Medicina y Ciencias de la Actividad Física y del Deporte, 16*(62), 203-219. https://doi.org/10.15366/rimcafd2016.62.002

Cenizo-Benjumea, J.M, Ravelo, J., Ferreras, S., & Gálvez, J. (2019). Diferencias de género en el desarrollo de la coordinación motriz en niños de 6 a 11 años. *RICYDE. Revista Internacional de Ciencias del Deporte, 15*(55), 55-71. https://doi.org/10.5232/ricyde2019.05504

Chacón-Borrego, F., Corral-Pernía, J.A., & Castañeda-Vázquez, C. (2020). Condición física en jóvenes y su relación con la actividad física escolar y extraescolar. *Revista Interuniversitaria de Formación del Profesorado, 34*(1), 99-114. https://doi.org/10.47553/rifop.v34i1.77077

Chiva-Bartoli, O., & Estevan, I. (2019). El sexo, el contexto familiar y la actividad física extraescolar como factores asociados a la coordinación motriz en la niñez. Un estudio piloto. *RYCIDE. Revista Internacional de Ciencias del Deporte, 15*(16), 154-170. https://doi.org/10.5232/ricyde2019.05603

Dalen, T., Ingvaldsen, R.P., Roaas, T.V., Pedersen, A.V., Steen, I., & Aune, T.K. (2016). The impact of physical growth and relative age effect on assessment in physical education. *European Journal of Sport Science, 17*(4), 482–487. https://doi.org/10.1080/17461391.2016.1268

Delgado-Lobete, L., & Montes-Montes, R. (2017). Relationship between psychomotor development and extracurricular sport practice among preschoolers. *Sportis*. *Scientific Journal of School Sport, Physical Education and Psychomotricity, 3*(1), 83-99. http://dx.doi.org/10.17979/sportis.2017.3.1.1770

Diamond, A. (2000). Close interrelation of motor development and cognitive development and of the cerebellum and prefrontal cortex. *Child Development, 71*(1), 44–56. https://doi.org/10.1111/1467-8624.00117

Ericsson, I. (2011). Effects of increased physical activity on motor skills and marks in physical education: an intervention study in school years 1 through 9 in Sweden. *Physical Education & Sport Pedagogy, 16*(3), 313-329. http://doi.org/10.1080/17408989.2010.545052

Ericsson, I., & Karlsson, M.K. (2012). Motor skills and school performance in children with daily physical education in school – a 9-year intervention study. *Scandinavian Journal of Medicine and Science in Sports, 24*(2), 273-278. http://doi.org/10.1111/j.1600-0838.2012.01458.x

Freitas, D.M., Lausen, B., Maia, J., Lefevre, J., Gouveia, É.R., Thomis, M., Antunes, A.P., Claessens, A., Beunen, G., & Malina, R.M. (2015). Skeletal maturation, fundamental motor skills and motor coordination in children 7–10 years. *Journal of Sports Sciences, 33*(9), 924-934. https://doi.org/10.1080/02640414.2014.977935

Freitas, D.L., Lausen, B., Maia, J., Gouveia, É.R., Thomis, M., Lefevre, J., Silva, R., & Malina, R.M. (2016). Skeletal Maturation, Body Size, and Motor Coordination in Youth 11–14 Years. *Medicine and Science in Sports and Exercise, 48*(6), 1129-1135. https://doi.org/10.1249/mss.0000000000000873

García-Marín, P., & Fernández-López, N. (2020). Association of the fundamental movement skills competence with the extracurricular sport and the body massindex in preschooler. *Retos. Nuevas Tendencias en Educación Física, Deportes y Recreación, 38,* 33–39. https://doi.org/10.47197/retos.v38i38.71896

Garrote-Escribano, N., & Villarroel, A.C. (2021). *Desarrollo motor humano*. Aula Magna.

Gómez-Campos, R., de Arruda, M., Hobold, E., Abella, C., Camargo, C., Martínez, C., & Cossio-Bolaños, M. (2013). Valoración de la maduración biológica: usos y aplicaciones en el ámbito escolar. *Revista Andaluza de Medicina del Deporte, 6*(4), 151-160. https://www.elsevier.es/es-revista-revista-andaluza-medicina-del-deporte-284-pdf-X1888754613647771

Gómez-Campos, R., Arruda, M., Luarte-Rocha, C., Urra, C., Almonacid, A., & Cossío-Bolaños, M. (2016). Enfoque teórico del crecimiento físico de niños y adolescentes. *Revista Española Nutrición Humana y Dietética, 20*(3), 244-253. https://dx.doi.org/10.14306/renhyd.20.3.198

González de Mesa, C., Cecchini, J.A., López, J., & Riaño, C. (2009). Disponibilidad de las Habilidades Motrices en escolares de 4 a 14 años. Aplicabilidad del test de Desarrollo Motor Grueso de Ulrich. *Aula Abierta, 37*(2), 9-28. https://dialnet.unirioja.es/servlet/articulo?codigo=3088554

Herlitz, M.J., Rodríguez, J., David, G., Carrasco-López, S., Gómez-Campos, R., Urra-Albornoz, C., Castelli Correia de Campos, L.F., Vega-Novoa, S., & Cossío-Bolaños, M.A. (2021). Relationship between motor coordination and body adiposity indicators in children. *Retos. Nuevas Tendencias en Educación Física, Deportes y Recreación, 39,* 125–128. https://doi.org/10.47197/retos.v0i39.78378

Hernández, J.L. & Velázquez, R. (2004). La *evaluación en educación física: investigación y práctica en el ámbito escolar*. Graó.

Herrera-Gonzalez, E. (2015). The Early Diagnosis of Boys and Girls in Academic Risk Using the Perceptual-Motor Diagnostic System: A Longitudinal Retrospective Study of Evidences of its Effectiveness. *Revista Electrónica Educare, 19*(3), 1-14. http://dx.doi.org/10.15359/ree.19-3.1

Hills, A.P., & Byrne, N.M. (2010). An overview of physical growth and maturation. *Medicine and Sport Science, 55*, 1–13. https://doi.org/10.1159/000321968

Hondt, E., Deforche, B., Gentier, I., Verstuyf, J., Vaeyens, R., De Bourdeaudhuij, I., Philippaerts, R., & Lenoir, M. (2014). A Longitudinal Study of Gross Motor Coordination and Weight Status in Children. *Obesity, 22,* 1505–1511. https://doi.org/10.1002/oby.20723

Jiménez-Pavón, D., Kelly, J., & Reilly, J.J. (2010). Associations between objectively measured habitual physical activity and adiposity in children and adolescents: systematic review. *International Journal Pediatric Obesity, 5*(1), 3-18. https://doi.org/10.3109/17477160903067601

Kambas, A., Michalopoulou, M., Fatouros, I.G., Christoforidis, C., Manthou, E., & Giannakidou, D. (2012). The relationship between motor proficiency and pedometerd-etermined physical activity in young children. *Pediatric Exercise Science, 24,* 34-44. https://doi.org/10.1123/pes.24.1.34

Latorre-Román, P.A., Mora-López, D., & García-Pinillos, F. (2018). Effects of a physical activity programme in the school setting on physical fitness in preschool children. *Child: Care, Health, and Development, 44*(3), 427-432. https://doi.org/10.1111/cch.12550

Lima, R., Bugge, A., Ersbøll, A., Stodden D., & Andersen, L. (2019). The longitudinal relationship between motor competence and measures of fatness and fitness from childhood into adolescence. *Jornal de Pediatría, 95*(4), 482-488. https://doi.org/10.1016/j.jped.2018.02.010

Luz, L., Cumming, S., Duarte, J., Cleiton, B., Santos, R., Seabra, A., & Coelho-E-Silva, M. (2026). Independent and Combined Effects of Sex and Biological Maturation on Motor Coordination and Performance in Prepubertal Children. *Perceptual and Motor Skills, 122*(2), 610–635. https://doi.org/10.1177/0031512516637733

Malina, R.M. (2004). Motor development during infancy and early childhood: Overview and suggested directions for research. *International Journal of Sport and Health Science, 2*(1), 50-66. https://doi.org/10.5432/ijshs.2.50

Malina, R.M. (2014). Top 10 research questions related to growth and maturation of relevance to physical activity, performance, and fitness. *Research Quarterly for Exercise and Sport, 85*, 157–173. https://doi.org/10.1080/02701367.2014.897592

Malina, R.M., & Rogol, A. D. (2011). Sport training and the growth and pubertal maturation of young athletes. *Pediatric Endocrinology Reviews, 9*(1), 441-455. https://pubmed.ncbi.nlm.nih.gov/22783642/

Mirwald, R.L., Baxter-Jones, A.D., Bailey, D.B., & Beunen, G. (2002). An assessment of maturity from anthropometric measurements. *Medicine and Science in Sports and Exercise, 34*(4), 689-694. https://doi.org/10.1097/00005768-200204000-00020

Morales-Vallejo, P. (2011). *Estadística aplicada a las ciencias sociales*. Universidad Pontificia Comillas.

Réa, N., Okelyb, A., Logan, S., da Silva M.M.L.M., Cattuzzo, M.T., & Stodden, D.F. (2020). Relationship between meeting physical activity guidelines and motor competence among low-income school youth. *Journal of Science and Medicine in Sport, 23*(6), 591-595. https://doi.org/10.1016/j.jsams.2019.12.014

Reyes, A., Chaves, R., Baxter-Jones, A., Vasconcelos, O., Barnett, L., Tani, G., Hedeker, D., & Maia, J. (2019). Modelling the dynamics of children's gross motor coordination. *Journal of Sports Sciences, 37*(19), 2243-2252. https://doi.org/10.1080/02640414.2019.1626570

Reverter, J., Plaza, D., Jové, M., & Hernández, V. (2014). Actividad físico-deportiva extraescolar en alumnos de primaria: el caso de Torrevieja (Alicante). *Retos, Nuevas Tendencias en Educación Física, Deportes y Recreación, 25,* 48-52. https://www.redalyc.org/articulo.oa?id=345732291010

Rosa-Guillamón, A., García-Canto, E., & Martínez-García, H. (2020). Analysis of global motor coordination in schoolchildren according to gender, age, and level of physical activity. *Retos. Nuevas Tendencias en Educación Física, Deportes y Recreación, 38,* 95–101. https://doi.org/10.47197/retos.v38i38.73938

Ruiz, L.M. (2004). Competencia motriz, problemas de coordinación y deporte. *Revista de Educación, 335,* 21–34. https://dialnet.unirioja.es/servlet/articulo?codigo=1066525

Ruiz-Pérez, L.M., Rioja-Collado, N., Graupera-Sanz, J.L., Palomo- Nieto, M., & Garcia-Coll, V. (2015). Grami-2: desarrollo de un test para evaluar la coordinación motriz global en la educación primaria. *Revista Iberoamericana de Psicología del Ejercicio y el Deporte, 10*(1), 103-111. https://dialnet.unirioja.es/servlet/articulo?codigo=4926264

Santos, A., Neto, F., & Pimenta, R. (2013). Evaluation of motor skills in children participating in social/sports projects. *Motricidade, 9*(2), 50-60. https://doi.org/10.6063/motricidade.2667

Skowroński, W., Skowrońska, M., Rutkowska, I, Bednarczuk, G., Kaźmierska-Kowalewska, K., & Marszałek, J. (2019) The effects of extracurricular physical education classes on gross motor development in primary school children – pilot study. *Biomedical Human Kinetics, 11,* 136–143. https://doi.org/bhk-2019-0019

Shumway-Cook, A., & Woollacott, M. (2007). *Motor Control: Translating research into clinical practice* (3rd ed.). Lippincott Williams & Wilkins.

Smits-Engelsman, B.C.M, Henderson, S., & Michels, C. (1998). The assessment of children with Developmental Coordination Disorders in the Netherlands: The relationship between the Movement Assessment Battery for Children and the KÖrperkoordinations Test für Kinder. *Human Movement Science, 17*(4-5), 699-709. https://doi.org/10.1016/S0167-9457(98)00019-0

Suárez-Ortega, C.M., & Moreno-Carmona, N.D. (2022). Incidence of extracurricular sports activities in school processes and in socio-family and psychological aspects of children and adolescents. *Retos. Nuevas Tendencias en Educación Física, Deportes y Recreación, 46*, 987–995. https://doi.org/10.47197/retos.v46.90471

Temboury, M.C. (2009). Desarrollo puberal normal. Pubertad precoz. *Revista Pediatría Atención Primaria, 11*(16), 127-142. https://scielo.isciii.es/scielo.php?pid=S1139-76322009000600002&script=sci_abstract

Torralba, M.A., Vieira, M.B., Lleixà, T., & Gorla, J.I. (2016). Assessment of motor coordination in primary bducation of Barcelona and province. *Revista Internacional de Medicina y Ciencias de la Actividad y el Deporte, 16*(62), 355-371. http://dx.doi.org/10.15366/rimcafd2016.62.011

Valdivia, A., Lara, R., Espinoza, C., Pomahuacre, S., Ramos, G., Seabra, A., & Garganta, R. (2018). Prontitud, coordinativa: perfiles multivariados en función de la edad, sexo y estatus socio-económico. *Revista Portuguesa Ciencias do Desporto, 8*(1) 34–46. https://www.researchgate.net/publication/255644689_Prontitud_Coordinativa_perfiles_multivariados_en_funcion_de_la_edad_sexo_y_estatus_socio-economico

Valentini, N., Logan, S., Spessato, B., Santayana, M., Pereira, K., & Rudisill, M., (2016). Fundamental motor skills across childhood: Age, sex, and competence outcomes of Brazilian children. *Journal of Motor Learning and Development, 4*(1), 16 -36. http://dx.doi.org/10.1123/jmld.2015-0021

Wang, G., Li, W., & Dou, K. (2020). Extracurricular sports participation increases life satisfaction among Chinese adolescents: A moderated mediation model. *Social Behavior and Personality: An International Journal, 48*(8), 1-11. https://doi.org/10.2224/sbp.8993

Zwicker, J.G., Missiuna, C., Harris, S.R., & Boyd, L.A. (2010). Developmental coordination disorder: A review and update. *European Journal of Paediatric Neurology, 14*(6), 573–581. https://doi.org/10.1016/j.ejpn.2010.07.005