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Original Article

Motor coordination assessment of U13 soccer players

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Abstract
Problem Statement: Athletes with the highest level of coordination training demonstrate the best efficiency of game activity (Boichuk, 2017). Technique training has had a combined effect of both conditional and coordinative physical capacities to improve the level of dexterity in sports (Demcenco, 2017; Massafret & Serrés, 2004). The KörperkoordinationsTest für Kinder (KTK) has been a valuable instrument for evaluating gross motor coordination in children wing to its valid, reliable, low-cost, and useful characteristics, both for research and practice. *Approach*: This study aimed to determine the level of motor coordination (MC) in under-13-year-old soccer players (U13) with KTK test and to analyze the results in points and total motor coefficient (TMco) compared to those of previous studies. *Material and Methods:*A quantitative study was performed using a correlational scope. First, 25 children from the Coofisam Soccer School in Tarqui, Colombia participated; age: 12.57 years ± 0.66, height: 1.49 m ± 0.07, body mass: 45.04 kg ± 10.09, and body mass index (BMI): 20.38 ± 3.20. A *sample t-test* was applied to compare the results with a Belgian study (Vandorpe et al., 2011). MC and BMI were related to Pearson's coefficient (*r*). *Results:* The TMco (289.76 ± 35.34) results corresponded with a record of 91 and a normal MC classification. The point score of theU13 soccer players (172.48 ± 31.56) differed significantly from that of Belgian children (226.05), $t(24) = -8.48$, $p<.05$, $r = .86$. A negative association was found between BMI and MC at points, $r = -.415$, $p<.05$ and TMco, $r = -.485$, $p<.05$.*Conclusions:*U13 soccer players have *normal motor coordination* of 72% and *moderate motor disorder* of 28%. The MC classification was lower compared to that for Belgian children, who present a *good coordination* classification. U13 soccer players with higher BMI showed a lower MC.
Key words: **classification, coordination abilities, KTK test, technique**

Introduction

Soccer is a very popular sport and a cultural element of the masses worldwide, it is also a constant field of research in which many authors work in different fields of study. This is the case for Castelo (2009), who mentioned the high level of specialization in soccer, and Rivas (2010), who highlighted the importance of technique in soccer performance. Additionally, Massafret and Serrés (2004) and Mazón et al. (2017) mentioned the importance of coordination abilities for learning sports techniques, which is favored by the integral work of those capacities (Meinel & Schnabel, 2004). In a sport, such as soccer, one must first work to make sure that each subject can develop and train coordination (Ceruso et al., 2019).

Soccer has reached a high level of specialization and professionalization, evolving in all its aspects for continuous improvement and performance (Castelo, 2009). One of these aspects is technique, understood as the movements or actions that the soccer player performs to handle the ball even in the most stressful situations of competition (Rivas, 2010). The athletes with the highest level of coordination training demonstrate the best efficiency of game activity (Boichuk, 2017). Technique training has had a combined effect on conditional and coordinative physical capacities to improve the level of dexterity in sports (Demcenco, 2017; Massafret & Serrés, 2004).

To practice certain sports, such as soccer, it is necessary to develop specific aspects of coordination abilities; for example, working comprehensively on two capacities or more at the same time favor learning of sports technique (Meinel & Schnabel, 2004). Mazón et al. (2017) showed the importance of the development of coordination in the improvement of the technical foundations of soccer in children 10 to 12 years of age. Accordingly, the development of coordination has a positive influence on the improvement of soccer techniques.

Le Boulch (1971) used the term motor coordination (MC) to classify the types of motor tasks and describe the components of coordination as the association of muscles with the intention of an outcome. Other

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authors affirmed that MC is a significant condition in the execution of a movement and the improvement of sports skills (Meinel & Schnabel, 2004).

MC has been studied extensively in recent decades (Panagopoulou et al., 2008); although it is not easy to establish useful tests to measure and evaluate coordination, as it is linked to other capacities (Mazón et al., 2017). Kiphard and Schilling (1974, 2007) proposed The KörperkoordinationsTest für Kinder (KTK) to assess MC and identify motor delay in boys and girls 5 to 14 years of age (Kiphard & Schilling, 1976). The KTK test has been a valuable instrument for evaluating gross MC in children (Vandorpe et al., 2011), because it is a, valid, reliable, and low-cost test, and it has been used in several countries owing to its useful characteristics, both for research and practice (Moreira et al., 2019)

Some researchers have investigated the test retest reliability coefficient for the total KTK test and have found values of r = .90 and .97 (D'Hondt et al., 2013), r = .80 and .96 (Jaakkola et al., 2017), and r = .97 (Lopes et al., 2012). Similarly, the same creators of the battery reported a reliability coefficient for the total of the test of r = .90 and a validity coefficient of r = .70 (Kiphard & Schilling, 1976).

Alarcón and Padilla (2017) performed a meta-analysis of the KTK test in boys and girls 6 to 11 years of age. In their analyzed studies, they found that all had an average Pearson correlation coefficient of r = .981, which indicated that all the studies showed similarity in their results. In the same way, the authors found that the KTK test was designed correctly and that children between 6 and 11 years of age presented a similar level of motor development regardless of the context (country) where it was applied.

The KTK test has been used to evaluate MC in children and relate it to different study variables. Söğüt (2017) related the speed of the tennis serve and the level of coordination between elite players and players with a lower level of performance (11 to 14 years) and found that the level of MC in elite players was significantly higher with respect to lower-performing players. Jaakkola et al. (2017) studied the differences in the coordination abilities between young gymnasts, swimmers, and hockey players; they found that the results among the athletes of the different modalities varied significantly due to the highly specific training in representative skills of each sport. Söğüt (2016) also studied the development of MC and its relationship with the age and gender of tennis players and found that there were no differences in coordinative performance between genders.

The KTK test was designed in 1974, and despite its age, it has remained in force because it continues to be used to evaluate MC in large populations (D'Hondt et al., 2013; Lopes et al., 2012; Söğüt, 2016; Torralba et al., 2016; Vandorpe et al., 2011). Thus, this test, which has been in use for more than 40 years justifies its applicability and validity by itself (Braz, 2017). In this sense, it is considered relevant to evaluate CM with the KTK test in soccer training processes.

Kiphard and Schilling (1974) proposed the KTK test, and they applied it to 1228 German boys and girls between 5 and 14 years old and proposed reference values for the evaluation of the MC level. Subsequently, Vandorpe et al. (2011) evaluated 2470 Belgian boys and girls 6 to 12 years of age with the KTK test and analyzed the results in relation to the previous study carried out by Kiphard and Schilling (1974). Consequently, the purposes of this study were to determine the MC level in soccer players under 13 years (U13) of age with the KTK test to analyze the results obtained in points (raw) and in total motor coefficient (TMCo) values with respect to those from previous studies

Material and Methods

Experimental approach for the problem

A quantitative study was performed using a correlational scope.

Participants

Twenty-five children from the Coofisam Soccer School in the town of Tarqui, Colombia participated in the study. The inclusion criteria to participate in the study were: being enrolled in the soccer school, being between 11 and 13 years of age, attending all the KTK tests, being a healthy child who did not present injuries or illnesses that prevented them from performing the test practices, authorizing of their participation under the assented consent, and those for whom their legal representative or their parents signed the informed consent. The research followed the code of ethics of the Declaration of Helsinki (World Medical Association, 2013) and took into account the guidelines of the National Ministry of Health (1993), which considers the research to be of minimal risk because it is a non-invasive study.

Procedures

The group of U13 soccer players was identified with the following variables: age, height, body mass, and body mass index (BMI). To establish the age, the decimal age was taken into account (Zatsiorski, 1989), which is determined by relating the date of birth and the date of registration of the evaluations. To find height and body mass, the protocols of the International Society for the Advancement of Kineanthropometry (ISAK) were applied, which are described in Marfell-Jones et al. (2011). The protocols were applied by the medical staff of the Tarqui Hospital.

Height was measured with a wall roll-up tape measure (Seca® 206). Body mass was established with a brand round dial mechanical floor scale (Seca® 761). To determine the BMI, the following formula was used:

BMI = mass (kg) / height (m) 2 (Whaley et al., 2017). MC was evaluated with the KTK test proposed by Kiphard and Schilling (1974, 2007). The battery has standardized protocols for children between 5 and 14 years of age, from which the following evaluations were extracted: Rearguard Balance (RB), One Foot Jumps (MJ), Lateral Jumps (LJ), and Lateral Transposition (LT). For the RB test, three wooden stringers that were 3-m long, 3-cm high, and widths of 6 cm, 4.5 cm, and 3 cm were used as material for each stringer. The beams were supported by transverse supports that were 0.5 m apart from each other with the beam being raised 5 cm from the ground. The ER test consisted of walking to the rear on three stringer of different widths. The movements were made in decreasing order of the widths of the beams. Before valid attempts, those evaluated practiced a previous exercise to adapt to the test, in which the participant performed a forward movement and a backward movement. During the displacement, it was not allowed to touch the ground with the feet. For the score on each crossbar, three valid attempts were counted, for a total of nine attempts. The number of supports on the crossbar in the backward movement was counted with the following indication: the evaluated participant was standing on the board, and, the first support was not scored as an evaluation, but only from the moment of the second support was the execution valued. The evaluator counted aloud the number of supports performed until one foot touched the ground or until eight points were made. In each crossbar, they could only score eight points for each valid attempt, with 72 points being the maximum possible score. The result was equal to the sum of the back supports in the nine attempts.

In the MJ test, 12 foam plates (50 cm × 20 cm× 5 cm) were used. The exercise consisted of hopping on one foot (first with the skillful foot and then with the non-skillful one) over one or more overlapping foam plates placed transversely to the direction of the jump. The evaluated participant began the jump according to the recommended height for the age of 11 to 14 years, which was 35 cm (seven plates). In the event that the evaluated participant did not obtain success in the initial height of the test, he had to go back 5 cm in height until he was successful. The evaluated participant performed the jump with one foot and could have adequate space to propel himself (approximately 1.5 m). The reception was made with the same foot with which he started the jump and was not able to touch the ground with the other. Three opportunities were allowed at each height to execute the jump (if the first one was not exceeded) with a trial of two attempts with each foot. Three points were attributed in the first attempt when the evaluated participant fell correctly with the indicated foot, in the second attempt two points were assigned when correctly landing with the corresponding foot, in the third attempt, a point was assigned if the participant managed to land successfully with the correct foot, and zero points were assigned when he failed in the attempt. The result was equal to the sum of the points obtained with the right foot and with the left foot for all the evaluated heights, and three more points were awarded for each plate placed from the initial height of the test. The maximum possible score was 72 points.

The LJ test was performed using a stopwatch, and a 1 m × 0.6 m rectangular wooden plate and a 60 cm × 4 cm × 2 cm obstacle was placed in such a way as to divide the rectangle into two equal parts. The exercise consisted of jumping laterally with both feet together, from one side of the obstacle to the other for 15 s as fast as possible without touching the obstacle and falling within a defined area. Five jumps were performed as a trial.

Two valid attempts were allowed with 10 s of intervals between them. If the evaluated person touched the obstacle, made the reception outside the delimited area, or the duration of the test was interrupted, the evaluator had to make an order to continue. If the faults persisted, the test was interrupted and a new demonstration was performed. Only two valid attempts were allowed. The score was counted with the number of jumps performed correctly in two attempts, and the result was equal to its sum.

The LT was evaluated using a stopwatch and two wooden plates (25 cm × 25 cm × 1.5 cm), and in the corners, four 3.5-cm high bases were added. The platforms were placed on the ground in parallel with one next to the other with a separation of 12.5 cm between them. The test consisted of the lateral transposition of the platforms for 20 s for as many times as possible, and two valid attempts were allowed. The evaluated participant stood on one of the platforms, for example, to the one on the right side. At the signal of departure, he took with both hands the platform that was on his left side to place it on the right side. Next, he would transfer his body to that platform and repeat the sequence. The direction of movement was chosen by the appraiser, and the first point was counted when the appraiser placed the platform on the other side and immediately placed both feet on top of it. If during the exercise the evaluated person touched the ground with his hands or feet, the evaluator gave the indication to continue. The evaluator had to count the points out loud during the execution of the test within the time limit. The number of transpositions corresponded to the number of points. The points of the two valid attempts were added.

To determine the total score of the KTK test, the points that the evaluated participant obtained in each of the tasks were noted, as follows: number of steps (RB), points obtained (MJ), number of jumps (LJ), and number of times that he executed a movement (LT). The points obtained were added to establish the total score of the battery (raw score) to maintain absolute differences between the participants (Bustamante et al., 2008; Invernizzi et al., 2018). In addition, the KTK test total score has also been used to follow children's CM development over time or to test the effects of the intervention in research (Iivonen et al., 2015; Sääkslahti & Laukkanen, 2015). Additionally, the score obtained in each of the four tests (ER, SM, SL, and TL) was assigned a motor coefficient (MCo), which originated from the reference values of the test by gender and age of those

evaluated. From the sum of the MCo of each test, the total motor coefficient (TMCo) was obtained; then, that TMCo corresponded to a record that allowed the MC to be classified according to the criteria stipulated in Table1

Table 1

*Classificationof motor coordinationwiththe KTK test**

Register	Classification	Percentile
131 - 145	Verygoodcoordination	99 to 100
116 - 130	Good coordination	85 to 98
86 - 115	Normal coordination	17 to 84
71 - 85	Moderate motor disorder	3 to 16
56 - 70	Severe motor disorder	0 to 2

Note. KTK: TheKörperkoordinationsTestfürKinder, *: Adapted by Kiphardand Schilling (1974, 2007).

The final record obtained in the evaluation was used to identify coordination problems and to indicate the level of MC in boys and girls (D'Hondt et al., 2013; Jaakkola et al., 2017; Lopes et al., 2012). In the present study, the results of the KTK test were reported in points and in MCo or TMCo.

Statistical analysis

Data were processed using the statistical package for the social sciences IBM® SPSS Statistics version 26.0. The normality of the distribution in the variables was verified using the Shapiro Wilks test. Descriptive statistics were calculated and presented as mean ± standard deviation (M ± SD), the median, and the interquartile range. To compare the results with other studies, the one-sample t-test was applied. MC and BMI were related by applying Pearson's correlation coefficient (r) and the determination coefficient (R 2). The level of statistical significance was adopted as a p-value < .05.

Results

In total 25 children from the Coofisam Soccer School in Tarqui, Colombia participated (age: 12.57 years ± 0.66, height: 1.49 m ± 0.07, body mass: 45.04 kg ± 10.09, and BMI: 20.38 ± 3.20). Overall 52% (n = 13) of the U13 soccer players were within the normal ranges of the established cut-off point (-1 ≤ SD ≤ 1) and 48% (n = 12) were overweight (De Onís et al., 2007).

The variables studied in the group of U13 soccer players showed normal values for the Shapiro Wilk test because non-significant (ns) differences were observed for age: D(25) = 0.96, D(25) = 0.97, ns. Height: D(25) = 0.97, ns. Weight: D(25) = 0.96, ns. BMI: D(25) = 0.94, ns. The result of the KTK test points was D(25) = 0.94, ns, and the result of the TMCo was D(25) = 0.98, ns.

Table 2 presents the total results of the KTK test and of each of the four tests in the group of U13 soccer players

Table 2

KTK test results for U13 Soccer Players

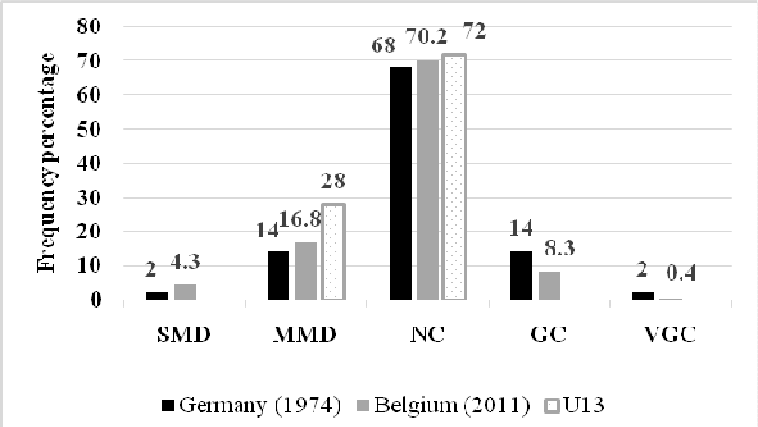
Test	Values	Mean	*ED*	P75	Median	P25
RB	Points	56.76	9.67	64.00	58.00	48.50
	MCo	100.80	12.50	110.00	103.00	91.00
MJ	Points	24.88	9.47	34.00	26.00	17.00
	MCo	44.28	8.80	49.00	45.00	39.00
LJ	Points	65.68	18.02	78.50	72.00	52.50
	MCo	98.20	22.80	116.00	105.00	82.50
LT	Points	25.16	3.59	27.50	25.00	22.00
	MCo	46.48	3.80	49.50	47.00	44.50
KTK total	Points	172.48	31.56	193.00	176.00	155.50
	TMCo	289.76	35.34	315.50	294.00	267.50

*Note.*KTK: TheKörperkoordinationsTestfürKinder, RB: Rearguard Balance, MJ: One Foot Jumps, LJ: Lateral Jumps, LT: Lateral Transposition, MCo: motor coefficient, TMCo: total motor coefficient, P75: 75th percentile, P25: 25th percentile.

The total result of the KTK test in U13 soccer players, which was measured in TMCo (289.76 ± 35.34), corresponded to a record of 91. In relation to Table 1, this resulted in a classification of *Normal Coordination* (NC); the group of Belgian children (*n* = 199) of the same gender and age as the U13 soccer players obtained anaverage TMCo result of 395.92; this value corresponds to a record of 118 and a classification of *Good Coordination* (GC).

Figure 1 shows the distribution of the MC development level in the U13 soccer players, as measured with the KTK test. As shown, 72% of U13 soccer players presented a NC level, and 28% had moderate motor disorder (MMD). Figure 1 also includes the evaluations made by Kiphardand Schilling (1974) and Vandorpe et al. (2011).

Figure 1 - *Frequency of classification of motor coordination by Kiphardand Schilling*



Note. SMD: Severe motor disorder, MMD: Moderate motor disorder, NC: Normal coordination, GC: Good coordination, VGC: Verygoodcoordination.

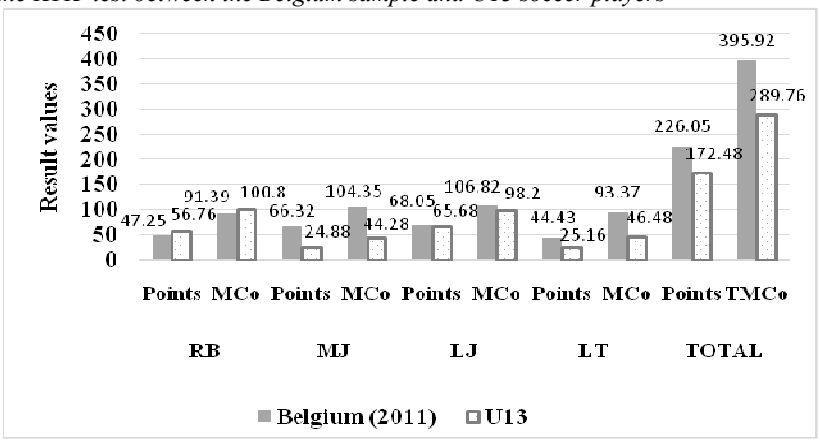
None of the U13 soccer players showed good levels of MC; however, 8.7% of Belgian children registered good and very good coordination in contrast to 16% of German children who scored above average. In the group of U13 soccer players, the Pearson correlation coefficient was applied between the BMI result (20.38 ± 3.20) and the MC result measured in points (172.48 ± 31.56) and TMCo (289.76 ± 35.34). A negative association was found between MC and BMI, i.e., the higher the BMI, the lower the CM development level and vice versa. A trend of negative association was found for the results of the KTK test in points, $r = -.415$, $p < .05$ and TMCo, $r = -.485$, $p < .05$. These correlation values, expressed in R 2 , were R 2 = .172 for the results in points and R 2 = .235 for the TMCo. This indicated that the amount of variability shared by BMI and MC, as expressed in percentage terms, were 17% and 23% for the results of the KTK test in points and TMCo, respectively.

Discussion

The main purpose of this study was to determine the MC level in U13 soccer players from the Coofisam Tarqui School, Colombia. According to the results of the KTK test, measured in TMCo, the U13 soccer players presented a Normal Motor Coordination level. When the results were analyzed in relation to previous studies (Vandorpe et al., 2011), the U13 soccer players were classified with a lower level of MC compared to Belgian children, who presented a Good Coordination level. According to our analysis, this is the first study that compares the results of the KTK test applied to a group of U13 soccer players with those from previous studies. The results of the group of U13 soccer players were compared with the values for normal development in Belgian children (n = 199) of the same gender and age; for this, the one-sample t-test was applied with the average as the reference value, which is shown in Figure 2. The average result in points of the KTK test for Belgian children (226.05) differed significantly from that performed by the U13 soccer players (172.48 ± 31.56), $t (24) = -8.48$, $p < .05$, $r = .86$. Similarly, the average TMCo result for the KTK test of Belgian children (395.92) also differed significantly from that of the group of U13 soccer players (289.76 ± 35.34), $t (24) = -15.01$, $p < .05$, $r = .95$

Figure 2

Comparison of the KTK test between the Belgium sample and U13 soccer players



Note. KTK: The Körperkoordinations Test für Kinder, MCo: motor coefficient, TMCo: total motor coefficient, RB: Rearguard Balance, MJ: OneFootJumps, LJ: Lateral Jumps, LT: Lateral Transposition.

Upon comparing the results of the tests that make up the KTK test and the BMI values between the Belgian children and the group of U13 soccer players, the Belgian children had better performance in three (MJ, LJ, and LT) of the four tests. Additionally, the Belgian children had a lower BMI compared to the group of U13 soccer players. Upon applying the one-sample t-test, the BMI result in Belgian children (18.08 ± 2.97) differed significantly from that of U13 soccer players (20.38 ± 3.20), $t(24) = 3.59$, $p < .05$, $r = .30$. This difference may presumably influence the lower performance of the three tests for the group of U13 soccer players; some studies report that children with normal weight have higher TMCo values than children who are overweight and have obesity (D`Hondt et al., 2013; Lopes et al., 2012).

When the BMI values (20.38 ± 3.20) were related to the result of the MC measured in points (172.48 ± 31.56) and TMCo (289.76 ± 35.34) in the U13 soccer players, a negative association was found. Although, BMI is significantly related to MC ($p < .05$), this only equates to 17% to 23% of the variation in BMI values. These results are in agreement with the results of Willwéber and Čillík (2017), who confirmed the dependence ($p < .05$) of parameters of body composition and coordination abilities in boys and girls between 6 and 7 years of age. Ljubojević and Bojanić (2016) also showed that morphological characteristics are important for the results of coordination tests with students (boys) from the 7th grade of an elementary school in Danilovgrad.

The KTK test has been applied in longitudinal (D`Hondt et al., 2013) and cross-sectional studies (Bustamante et al., 2008), which confirmed the existence of a gradual improvement in MC as boys and girls of child youth ages increase in age. The group of U13 soccer players was older (12.57 years ± 0.66) than the group of Belgian boys (11 years). This difference in age may influence the RB test result, which was higher in the group of U13 soccer players, because of the overwhelming evidence that the level of MC increases with age both in trained (Soügüt, 2016) and untrained children (Bustamante et al., 2008).

The MC values found in the group of U13 soccer players in the KTK test reveal a worrying situation when finding a significant percentage of children with levels of MMD (28%). In this way, it was detected that the coordinative aspect did not worked specifically in the sports training process in the Coofisam Soccer School nor in the physical education classes. However, it has been demonstrated that developing a program of coordination training contributed to a significant increase in the level of technical preparedness for rugby (Rovniy et al., 2018), volleyball (Boichuk, 2017; Kozina et al., 2018), and basketball (Demcenco, 2017).
However, the sample of the group of U13 soccer players ($n = 25$) was lower than the sample in the studies carried out by Kiphard and Schilling (1974) and Vandorpe et al. (2011). Therefore, the difference in the results of the KTK test between these studies could have increased if a greater number of children had been evaluated in this study; however, this is a possible hypothesis that must be tested. Meanwhile, the group of U13 soccer players showed a high average BMI (48% overweight), which may have negatively influenced the KTK test results

Conclusions

For our group of U13 players from the Coofisam Tarqui Soccer School, we found a normal motor coordination level in 72% and moderate motor disorder in 28%, as measured with the KTK test in TMCo. Upon analyzing the results of the MC with respect to the study by Vandorpe et al. (2011), a lower level of MC was observed in the group of U13 soccer players. This was in terms of the results in both points and TMCo. Taking into account the previous analysis, it is important to explicitly incorporate specific work related to coordinative capacities in the curricular program of sports schools to improve the level of MC in children of infant youth ages.

Similarly, in the group of U13 soccer players, we found that BMI has an inverse relationship with MC, where soccer players with a higher BMI showed a lower MC compared to those of normal weight players. Generally, in children and adolescents, the older, the better MC development. However, if work on improving coordination abilities in sports training processes and/or physical education classes is added, the children's MC can improve considerably. Hence, it is importance to specifically develop coordination skills at these ages to allow children and young people to perform better both in their sports lives and in their daily tasks

Conflict of interests

The authors do not have any conflicts of interest that could alter the validity of the results presented.

Author contributions

Study conception and design: OM, MM, and JP. Application of evaluations and data collection: MM and JP. Statistical analysis of the data: OM. All the authors (OM, MM, and JP) analyzed and interpreted the results, wrote the manuscript, made a critical review, and approved the final version of the manuscript for publication.

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