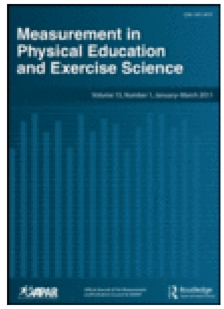

A Multimodal Analysis of Physical Factors that Influence Adolescents' Motor Competence

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Abstract

This study analyzed the factorial structure of motor competence tests designed to evaluate motor development among adolescents, focusing on two main dimensions of motor aptitude and coordination and motor control. To this end, we randomly sampled 1,026 adolescents (45.3% males; 45.7% females, age 13.75 years , *SD* = 1.28). Participants completed the Multidimensional Sportcomp Motor Battery with ten motor competence tests. Results indicate that two factors grouped seven of the ten sub-tests related to upper body strength and motor coordination. The factor structure remained stable across age and sex groups, with the exception of manual grip (grip strength) and 7 Meters with Feet Together (jumping) which may relate to a sexually evolutionary pattern for upper body force. The Flexibility, Equilibrium and Lateral Jumps tests were not grouped by this factor analysis on any established dimension. These results emphasize the multidimensionality of physical factors that influence motor competence among adolescents.

Keywords: Test, Motor Aptitude, Motor control, Factor Analysis, Adolescents

Introduction

Motor competence (MC) is a term used frequently and globally. It has been generally defined as the capacity for competence in a large number of motor skills that allow participation in a wide range of physical activities and motor acts (Castell & Valley, 2007; Haywood & Getchell, 2009; Stodden et al., 2008; Fransen et al., 2014). Additional research presents similar concepts of motor coordination, motor performance or fundamental movement skills (Luz et al., 2016; Robinson, 2015; Utesch & Bardid, 2019)

Adequate motor competence is a prerequisite for participation in physical activities for persons of all age groups (Cools et al., 2010; Chagas & Marinho, 2021; Fransen et al., 2014; Murgui et al., 2016), and acquiring MC at an early age is important for subsequent engagement in an active healthy lifestyle (Abarca-Sos et al., 2016; Cocca et al., 2014; Drenowatz et al., 2021; Luz et al., 2016; Robinson et al., 2015), meaning that developing motor competence is the main objective of children's physical education (Ruiz & Palomo, 2017).

In a meta-analysis of motor competence and participation in physical activities, Holfelder and Schott (2014) confirmed that there is a strong reciprocal relationship between motor competence and motor practice. Other studies conducted with children and adolescents indicate that youths with the lowest MC levels were less physically active and their athletic perception was lower than that of peers with higher-level motor skills (Barnett et al., 2009; Vedul-Kjelsas et al., 2015). The reciprocal relationship between practicing sport and engaging in physical activity and has been verified by other researchers, who have also attested to the essential nature of these activities for the proper development of MC (Chagas & Marinho, 2021; Kalaja et al., 2010), There is also a negative association between sedentary lifestyle and MC (Santos et al., 2021). In turn, these same youths with low MC scores present markedly reduced physical aptitude levels (Matvienko & Ahrabi-Fard, 2010; Stodden et al., 2009), understood as the ability to perform different activities efficiently delaying the onset of fatigue, and physical aptitude is compromised in adulthood (Matvienko & Ahrabi-Fard, 2010; Stodden et al., 2009). Conversely, poor physical condition negatively influences motor coordination (Cairney, 2015). In contrast, improvement in motor skills is associated with positive results on health, such as physical aptitude (Catuzzo et al., 2016), which is a relevant indicator of health and an excellent predictor of morbimortality among adolescents (García-Artero et al., 2007; Ortega et al., 2005).

Recently, given the close relationship between MC and physical activity, ongoing research has been conducted to elucidate the role of MC in active participation (Stodden et al., 2014). Early detection and assessment of children and adolescents with lower levels of MC than their peers are important (Fransen et al., 2014). Access to effective motor evaluation tools is also necessary to investigate the relationship between different health variables and mastering motor skills (Cano-Cappellacci et al., 2015).

A variety of tools have previously been employed to assess levels of MC among children and adolescents (Cools et al., 2008), most of which focus on identifying children with motor problems within clinical contexts (Cools et al., 2010). For example, Bruininks and Bruininks' BOT-2 (2005) evaluates fine and gross motor coordination and the KTK of Kiphard & Schilling (2007) measures gross motor coordination. However, Physical Education professionals currently lack reliable and accessible tools to assess motor competence and resort to using motor batteries focused on other objectives or that are time-consuming (Ruiz et al., 2017). In this respect, the school is widely recognized as an important setting for developing the skills, knowledge and behaviours oriented to physical activity and sport across lifespan (Sgro et al., 2019).

The Multidimensional Sportcomp Battery (Ruiz et al., 2010) was created to analyze MC levels among Secondary Education adolescent students. It is an evaluated quantitative-type instrument directed to outcome. It comprises 10 tests divided into two subgroups: five for motor aptitude (flexibility on a flexibility box, throwing a medicinal balloon, sit-ups in 30 seconds, manual grip and running up and back), and five for motor coordination (equilibrium on one leg, hopping with feet together over a 7-meter distance , hopping on one foot over a 7-meter distance, displacement over supports and lateral jumps). The original construct of motor competence is further subdivided into tasks that fall under three factors: locomotion, stability, and manipulation of objects (Gallahue & Ozmun, 2006, Stodden et al., 2014). However, some of the most frequently used instruments to assess motor competence obviate some of those three factors. Such is the case of Henderson and Sugden's M-ABC, Dale Ulrich's TGMD-2 or Khipard and Schilling's KTK, which mainly focus on gross motor coordination. The Sportcomp Multidimensional battery is proposed from the perspective of the physical factors that affect motor competence aspects indicated by Gallahue and Ozmun (2006). It also focuses on gross motor coordination, although it does not include one of the original factors, such as the manipulation of objects like the KTK. Various studies relate motor competence to physical fitness (Cairney et al., 2007, Fransen et al., 2014, Lubans et al., 2010, Matvienko and Ahrabi-Fard, 2010, Stodden et al. al., 2014). However, no previous study has measured motor competence by integrating the aforementioned dimensions posited from the perspective of physical factors that affect motor competence. In addition, MC is a very useful tool with numerous advantages for Physical Education teachers and researchers, given that it is comprehensive, time-efficient and requires accessible and inexpensive materials.

To date, the Multidimensional Sportcomp Battery has not undergone many validations. It was adapted by Arruza in 2011, but it maintained the factorial structure and was modified by Ruiz et al. (2017) to reduce the number of tests to contain only those that fitted the overall motor coordination construct. Therefore, an assessment of the psychometric properties of the test is warranted and thus the objective of this study is to evaluate the validity and reliability of the multidisciplinary battery Sportcomp with a sample of adolescents from Aragon. Moreover, we aimed to discern a representative pattern focused on the physical factors of motor competence and its application to study it according to gender and age. In this sense, previous research has analyzed the differences between boys and girls in their performance in different types of tests, but not the association between these tests, which will also be evaluated in this study.

Abundant previous research indicates sex-differences in CM among children and adolescents. The significant and systematic review carried out by Rodrigues et al. (2019) on nineteen studies, measured motor competence using the MABC instrument. The majority of findings indicate superior gross motor activities among boys and superior fine motor skills among girls. Other analyses of motor development carried out with different instruments have also revealed sex differences in favor of the males (Davies and Rose, 2000; Eather et al., 2018; Hardy et al., 2012; Vedul-Kjelsas et al., 2011). These differences have been interpreted from a biological point of view, mainly explained by a greater increase in absolute and relative strength among boys, but also from a social point of view, postulating that male children enjoy higher opportunities for physical activity in their free time (Luz, Cumming, et al, 2016; Menescardi et al., 2022; Pérez-Camacho et al., 2021), which can affect their motor development (Luengo, 2007).

In addition to biological sex, age is an important factor in the theoretical model of motor development of Gallahue and Ozmun (2006) which indicates that fundamental skills are established primarily between two to seven years of age. Specialized movements are established between 7 to 14 years, a period of development towards more complex movements applicable to daily life, recreation and different sports. The final stage, mainly during adolescence, the differences between the sexes skyrocket, especially for skills that require strength and power (Hornillos, 2000; Luz, Cumming, et al., 2016). However, analyses such as those of Milojevic and Stankovic (2010), García Mansó (1999) and Davies and Rose (2000) highlight that both sexes tend to display improvement through the end of puberty, with some evidence suggesting that progress for females slows at around 13 and for males around 15 (Schoemakery Kalverboer, 1994). Authors such as Sheehan and Lienhard (2019) emphasize that motor competence in pre-adolescent children may suddenly decrease after their growth spurt (Peak height velocity occurred at a significantly younger age in the girls (11 years) than the boys (13 years).

Methods

Participants

The participants of this study included adolescents from the Spanish Autonomous Community of Aragón who attended education centers in this geographical area, during their academic years 1 to 4 of ESO (compulsory Secondary Education). The sample was obtained by a random procedure in which provinces (Huesca, Zaragoza, and Teruel) and academic years (years 1 to 4 of ESO) were taken as strata. A sampling error of more/less 3% for the 95% confidence intervals was obtained by assuming P=Q=0.5. Originally data for 1048 individuals were obtained. Participants for whom no data were collected were eliminated and the remaining 1026 participants information was retained for analyses. Of these, 557 (54.3%) were male and 469 (45.7%) were females, aged between 12 and 17 years, the majority were 12-16 years old (99.3%). Their final mean age was 13.76 years (SD=1.27). The percentage of males and females in each age group did not statistically differ (χ^2=4,303, p=.367).

Variables and instruments

To evaluate MC, the Multidimensional Sportcomp Battery for MC was used (Ruiz et al, 2010). It was designed as a tool for Physical Education teachers of ESO to assess their students' MC and to provide instructors with data for the adaptation of teaching methods according to students' needs. This test comprises 10 tests subdivided into two groups: five motor aptitude tests (flexibility: sitting in front of a flexibility box and stretch as much as possible (cm), throwing a medicinal 2 kg balloon (cm), maximum number of sit-ups in 30 seconds, manual grip with a dynamometer (kg), running up and back over a 9-meter distance, picking up a balloon and returning to the starting point twice (seconds and tenths of a second); five coordination and motor control tests (maintaining equilibrium on one leg with eyes closed for a maximum 60-second time, covering a 3-meter length over supports (seconds and tenths of a second), hopping with feet together over a 7-meter distance (seconds and tenths of a second), hopping on one foot over a 7-meter distance (seconds and tenths of a second) and making as many lateral jumps as possible in for 15 seconds).

Procedure

First, the authors made contact with the education centers selected during the sampling. After contacting the centers' management and the Physical Education departments and obtaining their consent to participate in the research, adolescents' families were contacted to request their authorization for students' participation, taken as families' consent. Data were treated anonymously. A schedule to perform the tests in two phases was determined: the first phase was the motor test. All the tests were organized by students perusing degrees in Physical Activity and Sport Sciences who were specifically trained regarding the study and the content of the tests. The motor test was carried out individually, outside the class group, requiring approximately 15 minutes per student. This study was carried out in accordance with the recommendations of the Council of the British Educational Research Association in their Second edition of the Ethical Guidelines for Educational Research (BERA, 2011), given that in Spain there is currently no ethics specific committee for educational research. However, the protocol was approved by the Government of Aragon (Spain) in accordance with the proposal of the Advisory Council for Research and Development (CONAI + D) as part of an Aid for the development of Networks of Researchers, Mobility and Technological Research and Development Projects within the framework of cooperation of the Pyrenees Working Community (Ref.: CTPP06/09).

Statistical analysis

An exploratory factor analysis (EFA) and a confirmatory factor analysis (CFA) were carried out in two randomly created independent subsamples to obtain the factorial structure of the series of tests. Although other alternatives exist (e.g., the ESEM analysis) our sample size was large enough to randomly divide it into two subsamples with more than 500 participants each, permitting us to use this classic validation procedure (Lloret-Segura, Ferreres-Traver, Hernández-Baeza, & Tomás-Marco, 2014). This first part of the analysis was performed with SPSS software which employs the variances-covariances matrix and is suitable for continuous variables, such as those evaluated here.

The EFA for the first sample addressed the question of the number of factors from the parallel analysis. According to several authors, such as Abad, Olea, Ponsod, and García (2011, p.230), it is the most suitable method to establish the number of factors by comparing the self-values of the empirical solution with a random solution created from variables that are independent of one another. So factors with a higher self-value than was randomly obtained were retained in the analysis. To randomly obtain the value of the factors, the macro designed by O'Connor (2000) for SPSS was used.

Next the factorial matrix was obtained by applying the unweighted least squares (ULS) test that was least affected by assumed normality not being met than other alternatives like Maximum Likelihood. As Table 1 shows, two of the analyzed tests, i.e., Equilibrium and 7 Meters Feet Together, present asymmetry and kurtosis values diverge from normality. Nonetheless, sample size and the use of this estimation method would suffice to ensure stable estimations. The employed rotation method was the related factors option, specifically the option that SPSS offers by default, namely the oblimin method.

To run the CFA with the second subsample, M-plus was used with the same estimation procedure: (ULS). Fit was evaluated with the usual indices: the chi-square index (DCIM in AMOS) and the Norman chi-square index ($\chi 2$/DF), IFC, NFI or RMSEA (Byrne, 2010). Finally, whether the weight of this regression differed in distinct groups was tested by creating several SEM models and comparing those with the restrictions related to these values. When dealing with nested models, comparisons of the models were made by calculating $\Delta\chi 2$ (Byrne, 2010; McDonald & Ho, 2002) and the AIC index (Byrne, 2010). It was possible to check the two nested models using CFI when a difference of 0.01 was observed between models (Cheung & Rensvold, 2002).

To conduct the factorial invariance study we followed the recommendations of Byrne (2010) by establishing the model in all groups and performing a fit of the series.

In accordance with previously established methodology (Elosúa, 2005), the considered invariance levels referred to configural invariance and to metric and strict invariance.

Results

Table 1 presents the descriptive data of all ten tests considered. Most of the values obtained were relatively close to the mean, with sufficient dispersion to distinguish among participants. The asymmetry and kurtosis indices indicated conformance with the assumption of normality, with the exception of the aforementioned tests (Equilibrium and 7 Meters Feet Together), where we observed less widely dispersed values and a higher concentration around the mean, as indicated by high kurtosis values. There were statistically significant sex differences for all the items, except for Lateral Jumps. These differences favored males in all items, with the exception of the flexibility test, where females accomplished more centimeters on the box and, therefore, obtained higher scores, and no sex differences were observed in the aforementioned Lateral Jump test. Better scores were obtained by males in all the other tests (throwing a medicinal 2 kg balloon further, do more sit-ups in 30 seconds, perform more kg of static force, perform running up and back, 7 m hopping on one leg, 7 m hopping on both feet together over supports in less time, maintaining equilibrium on one leg longer than females. Considering the effect-sizes, these differences are large for all the tests and especially large in throwing a medicinal 2 kg balloon further and in covering a 3-meter length over supports, this last weaker than previous.

In the EFA, Kaiser-Meyer-Olkin (.850) and Bartlett's test of sphericity (Chi-squared=5185.727, p<.001) both indicated the non-independence of the items and the possibility of continuing with the EFA. Next, the number of factors to be considered in the analyses was established. To this end, the first subsample with 547 participants was used. The first CFA analysis indicated that there would be three self values higher than

1 (γ_1=4,326,γ_2=1,242, γ_3=1,074). As only two of the randomly created factors had self values below 1 (γ_1=1,216, γ_2=1,150, γ_3=1,100), a 2-factor solution was determined the most suitable. These two factors explained 55.5% of the variance of the ten MC items.

The 2-factor factorial structure that resulted from the EFA is shown in Table 2. The analysis of communalities indicated that two items, Flexibility and Equilibrium, were poorly related with the other tests, while Lateral Jumps presented a relatively low communality, although a factorial weight over 0.30 was estimated for this test in the second factor. Regarding the resulting factorial structure, the Medicinal Balloon (β=-.902) and manual grip (β=-.859) tests in the first factor saturated with high factorial loads. In the second factor, three tests saturated above .60: Hopping on one foot over a 7-meter Distance (β=.679), Running up and back (β=.646), Hopping with Feet Together (β=.641).The same occurred with other tests, whose values were slightly lower: Covering a 3-meter length over supports (β =.508), Lateral Jumps (β=-.506) and Sit-ups (β=.467). The correlation between both factors was modest (r=.339).

To supplement the factorial structure analysis, a series of CFAs was run to determine the structure that best fit the data. The data used to compare models are found in Table 3. An attempt to rule out unidimensionality of the tests by considering a 1-factor model (Model 1) in which the ten tests were saturated. led to fit problems and yielded RMSEA values over 0.80. Two models that were derived from the EFA were tested: Model 2 with three factors, which linked two items (the Flexibility and Equilibrium tests) in factor 3, which was not included in any of the EFA factors, plus two other factors with the items found in Table 2. Once again, the results of this new model were not acceptable and evidenced the poor relationship between Flexibility (β= .210) and Equilibrium (β=.236). None of the modification indices recommended them being included in either of the two previous factors. Thus, we propose the 2-factor

Model 3 with only eight items, as confirmed by the EFA, with which fit was much better, although item 10, Lateral Jumps, gave a much lower regression weight than the other items of factor 2 (β=.333). Thus Model 4 was considered, but only after removing this item. It also presented fit indices that could be assumed in the various indicators and improved the former model ($\Delta\chi^2$=70.052, 6 d.f. p<.001). Its factorial weights were all above 0.60 (Table 2). We stress the inverse value that the factor 2 tests presented, which indicates the inverse relationship between Sit-ups and all the other tests because the larger number of repetitions in the former represents a higher score, whereas for the remaining tests, lower scores indicate better performance.

Finally, a factorial invariance analysis was performed with sex and age. The results of both analyses are provided in Table 4. In both cases, the models that offered the best fit were observed for the partial metric invariance; that is, the models with strict invariance levels had poor fit indices, as was the case for the models that included only configural invariance. Thus, the best fit was indicated in metric invariance but was incomplete. Hence for sex, we observed that the model that assumed strict invariance had serious fit issues (CMIN/DF= 11.887; RMSEA=.151, CFI=.856, TLI=.841). A comparison of the models revealed that the model with assumed strict invariance was much poorer than the model which assumed only metric invariance ($\Delta\chi^2$= 342,147, 6d.f. p<.001). Analyses of metric invariance with configural invariance verified that there were no differences between either according to Chi-square comparison ($\Delta\chi^2$= 10,823, 5d.f. p=.055), but the RMSEA and CFI values were worse in the model assuming strict invariance in all items. Hence, we considered the option of exploring the models that assumed only partial metric invariance. After analyzing the configural model values, we found that items 4 and 9 presented the biggest intergroup differences. The various comparisons made of the models guaranteed this model's good fit as it was better than the model which assumed metric invariance in all the tests ($\Delta\chi^2$= 6.318, 2d.f. p=.025). The Akaike index values supported the assertion that this model was superior. The males in this model showed the closest association in the Dynamometry test (β=.790) than the females (β=.619), which was also the case with the 7 Meters Feet Together test (β_{males}=-.784; $\beta_{females}$=-.666).

Upon examining age, we once again observed that the model with the best fit was that which assumed partial metric invariance. Once more, the model that assumed strict invariance presented fit problems (CMIN/DF=5.247; RMSEA=.131, CFI=.884 TLI=.889). The comparison between the model assuming strict invariance was much worse than that assuming metric invariance ($\Delta\chi^2$= 304.001, 21d.f. p<.001) and no significant differences were detected between the models assuming configural and metric invariance ($\Delta\chi^2$= 18,231, 14d.f. p<.196). Thus, when we tested for improvement to the model if the factorial weight of some tests was released, we discovered that, once more, the manual grip and 7 Meters Feet Together presented the most different factorial weights. Nevertheless, at this stage. no model that released these tests, compared to the model assuming invariance in all the tests, proved better according to Chi-square analyses (Dynamometry: $\Delta\chi^2$= 6.035, 3d.f. p=.109; 7Meters Feet Together: $\Delta\chi^2$= 1.870, 3d.f. p=.598). However, the comparisons based on the CFIindex if (Δ=.01) revealed that the model which released the manual grip test improved the model with metric invariance in all items. This model also achieved improvements in other indicators like the Akaike index or RMSEA. The factorial weights of the different age groups revealed that the youngest adolescents ($\beta_{12\ years}$=.628; $\beta_{13\ years}$=.602) performing the manual grip tests were less associated with the Medicinal Balloon tests than the older adolescents were ($\beta_{14\ year}$s=.766; $\beta_{15\ years}$=.807).

Discussion

After performing the factorial structural analysis using EFA and CFA with the Multidimensional Sportcomp Battery, we propose a model that differs from the original of Ruiz et al. (2010), and also from the adaptation of Arruza et al. (2011), which were 2-factor models (physical aptitude and motor coordination) with the ten tests divided into five for each of these factors.

However, our results reduced the construct to two main factors composed of seven tests (two belonging to the first factor and five to the second), and three tests that did not group in any factor (Flexibility, Equilibrium On One Foot and Lateral Jumps), which become individual dimensions in the Battery. It is worth noting that the empirical analyses herein presented followed the recent suggestions made for the exploratory and confirmatory procedures (Lloret-Segura et al., 2014). Our methodological design was robust and entailed a large random sample of students who were in academic years 1-4 of the ESO of the Spanish education system. This allowed us to divide the sample into two different groups. We used complementary CFA in one case and EFA in another, which provided further consistency to our results. Another strength of our study is that our processes of statistical analyses included the most up-to-date recommendations for CFA and EFA (Lloret-Segura et al., 2014).

The physical aptitude factor was restricted to two upper-body force tests, and the Flexibility test independently. Within the force factor, on the one hand, the manual grip test allowed us to assess static force and, additionally, throwing a Medicinal Balloon which measured explosive strength. Thus, we named this factor upper body force. However, the name of the second factor remained unchanged despite some tests disappearing, e.g., Equilibrium, Lateral Jumps. Moreover, two tests which belonged to the first physical aptitude block were added to the tests Hopping on one foot over a 7-meter distance, Hopping with feet together over a 7-meter distance and Covering a 3-

meter length over supports. These two tests were Running up and back and Sit-ups in 30 seconds. The Running up and back test also measured agility, given the sum of speed and changes in rhythm, a capacity that has been included and is linked to complex coordinating capacities (Hernández, Velázquez, Martínez, Garoz & Tejero, 2011; Meinel & Schanbel, 2004; Sánchez, 2002) and to motor fitness factors (Gallahue & Ozmun, 2006). The Sit-ups test has always been used to measure force-resistance, which may be associated with this factor because being successful in it depends on performing rapid repetitions, which lead to changes in muscle contractions in a short time to achieve many sit-ups.

The factorial invariance results revealed quite a stable pattern for the factors' structure in the analyzed groups, particularly those related to the coordination factor and to motor control, where we found a weaker association with the 7 Meters Feet Together test only for females *versus* males. Conversely, the upper body force factor displayed a more heterogeneous pattern among the groups as the manual grip test was not invariant in either males or females, or the studied age groups. Our results may endorse a pattern of how upper body force elements evolved to be greater among males and the older age groups (aged 14 years and older). Regarding the upper body force factor results, some authors argue the non-existence of differences in force in males and females until they reach puberty (García, Navarro & Ruiz, 1996), when inequalities in explosive strength and maximum force begin to emerge around the age of 13 (Domínguez & Espeso, 2003; Hornillos, 2000); in adolescence, force in maximum and explosive strength terms permanently increases (García Mansó, 1999).

It is worth noting tests with higher factorial weight correlate well in the different age groups and sex with a large number of the rest. Such is the case of the round-trip test, which has a good correlation with the rest of upper-body strength and motor coordination tests in practically all age groups and both sexes, or medicine ball toss, which also has a strong relationship with manual grip and moderate to good grip with those that comprise the motor coordination factor, also among the different age groups and sexes. These two tests, together with 7 meters on the wrong foot, will provide useful information for Physical Education teachers and researchers who analyze adolescent CM from the perspective of this study, and also contribute valuable elements for testing the motor aptitude of adolescents. In all three cases, there is an important explosive strength component, making it a uniquely determining element of physical fitness in this particular age group, especially due to an increase in strength among both sexes during this developmental stage (Davies and Rose, 2000; García Mansó, 1999; Milojevic and Stankovic, 2010), although this increase is greater for males than females (Hornillos, 2000; Luz, Cumming, et al., 2016) and this sex difference is not observed in stages prior to puberty (García et al ., 1996).

Performances in the flexibility, balance and lateral jumps tests were not strongly associated with one another or with the other factors, which indicates that the physical factors that influence CM are not necessarily unitary, but are determined by various, relatively unrelated dimensions. It is worth noting tests with higher factorial weight correlate well with the majority of the remaining tests among the different age groups and sexes. For example, the round-trip test, which has a strong correlation with the rest of upper-body strength and motor coordination tests in practically all age groups and sexes, or medicine ball toss, which also has a strong association with manual grip and moderate to good grip with those that make up the motor coordination factor among the different age groups and sexes as well. These two tests, together with 7 meters on the wrong foot, will provide useful information to Physical Education teachers and researchers who analyze adolescent CM from the perspective of this study and are valuable elements for testing motor aptitude in this age group. In all three cases, there is an important explosive strength component, making it a strong predictive element of physical fitness among adolescents, especially due to increased strength in both sexes during this stage (Davies and Rose, 2000; García Mansó, 1999; Milojevic and Stankovic, 2010), although this increase is larger for males than for females (Hornillos, 2000; Luz, Cumming, et al., 2016) which is not observed in stages prior to puberty (García et al ., 1996).

Our findings indicate that the product of this research provides an instrument to assess adolescent CM that is comprehensive, time-efficient and requires accessible and inexpensive materials.

To further improve the utility of this measure, we recommend administering the battery collectively during Physical Education classes, thus reducing the estimated application time per student and avoiding the influence of tester fatigue on the execution of the tests. Moreover, our results demonstrate the measure's reliability and content validity, and that this instrument can be used by Physical Education teachers as well as researchers to investigate and measure motor competence. It is important to point out that the current education law in Spain (LOMCE) establishes motor competence as the main purpose of the Physical Education (PE) subject (MEC, 2014). For many PE professionals, assessing and promoting motor competence has become a factor of education that warrants great attention, as it favors the development of active lifestyles (Ruiz, De Vicente, Vegara, 2012).

Teachers have the chance to obtain information regarding physical aptitude components such as, classified as a predictor of cardio-metabolic morbid-mortality among adolescents (Ortega et al., 2005) which is integrated into other tests to measure motor competence (as in the case of Bruininks-Oseretsky BOT-2, 2005). Additionally, they can collect data on students' overall motor coordination. It is also essential to consider the multidimensionality of the physical factors that affect MC from the perspective proposed by Gallhueand Ozmun (2006) because, although the data for upper body force factors and coordination reveal a relationship between both, they cannot be simplified on a single dimension, given that three tests exist; Equilibrium, Flexibility and Lateral jumps, which did not diminish in previous tests.

This study has some limitations. The first two are that our sample was selected from among regional adolescents and we used a cross-sectional design, which can be overcome by extending the sample in subsequent studies both geographically (territories) and in terms of time (longitudinal study). Second, this instrument does not include any aerobic resistance test, which is an essential component in physical fitness factors. It may be that it was not included in Sportcomp to reduce the time required to complete all the tests. It would also be useful for future studies to assess the relationship and convergent validity of this instrument with other instruments often used to measure MC. Finally, other aspects of MC not included in this measure should be assessed further, such as handling objects, among others, which could be solved by combining those aspects with other instruments for such purposes, as recommended by Fransen et al. (2014), who advised against evaluating MC with only one instrument. Nonetheless, these limitations do not diminish the psychometric properties of this instrument. Our results firmly assert the utility of this instrument for the assessment of MC among adolescents of both sexes, 12 to 16 years of age, as evidenced by its qualities of validity, reliability, simplicity, as well as time and cost-effectiveness.

References

Abad, F.J., Olea, J., Ponsoda, V., & García, C. (2011). *Medición en Ciencias Sociales y de la Salud.* Madrid: Síntesis.

Abarca-Sos, A., Bois, J.E., Aibar, A., Julián, J.A., Generelo, E., & Zaragoza, J. (2016). Sedentary behaviors by type of day and physical activity in Spanish adolescents: A socio-ecological approach. *Perceptual and Motor Skills, 122* (1), 286–298.

Arruza, J. A., Irazusta, S., & Urrutia-Gutierrez, S. (2011). *Evaluación de la competencia motriz en los escolares de la Educación Secundaria Obligatoria de las regiones de la Comunidad de Trabajo de los Pirineos.* Universidad del País Vasco UPV/EHU.

Balaguer, I., Castillo, I., & Duda, J. L. (2008). Apoyo a la autonomía, satisfacción de las necesidades, motivación y bienestar en deportistas de competición: un análisis de la teoría de la autodeterminación [Autonomy support, needs satisfaction, motivation and well-being in competitive athletes: a test of the self-determination theory]. *Revista de Psicología del Deporte, 17*(1), 123-139.

Barnett, L. M., Van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2009). Childhood motor skill proficiency as a predictor of adolescent physical activity. *Journal of Adolescent Health, 44*, 252–259.

Barnett, L. M., Lai, S. K., Veldman, S. L. C., Hardy, L. L., Cliff, D. P., Morgan, P. J. Zask A., Lubans D.R., Shultz S.P., Ridgers N.D., Rush E., Brown H.L., & Okely A.D. (2016). Correlates of Gross Motor Competence in Children and Adolescents: A Systematic Review and Meta-Analysis. *Sports Medicine, 46*, 1663–1688.

Bruininks, R., & Bruininks, B. (2005). *Bruininks-Oseretsky Test of Motor Proficiency.* NCS Pearson (2nd Edition).

Cairney, J., Hay, J., Faught, B., Flouris, A., & Klentrou, P. (2007). Developmental Coordination Disorder and Cardiorespiratory Fitness in Children. *Pediatric exercise science. 19*, 20–28.

Cano-Cappellacci, M., Aleitte, F., & Durán, J. (2015). Confiabilidad y validez de contenido de test de desarrollo motor grueso en niños chilenos. *SaúdePública, 49* (97), 1–7.

Castelli, D. M., & Valley, J. A. (2007). The relationship of physical fitness and motor competence to physical activity. *Journal of Teaching in Physical Education, 26*, 358–374

Cairney, J. (2015). *Developmental Coordination Disorder and its Consequences*. Toronto, ON: University of Toronto Press.

Catuzzo, M.T., Henrique, R. S., Re' A.H.N., de Oliveira, I. S., Melo, B. M., Moura, M. S., Araujo, R.C., & Stodden, D. (2016). Motor competence and health related physical fitness in youth: A systematic review. *Journal of Science and Medicine in Sport, 19*, 123–129.

Chagas, D. D. V. & Marinho, B. (2021). Exploring the Importance of Motor Competence for Behavioral and Health Outcomes in Youth. *Percept Mot Skills, 128*(6):2544-2560. https:/doi.org/10.1177/00315125211050631

Cocca, A., Liukkonen, J., Mayorga-Vega, D., & Viciana-Ramírez, J. (2014). Health-related physical activity levels in Spanish youth and young adults. *Perceptual and Motor Skills, 118* (1), 247–260.

Cheung, G.W., & Rensvold, R.W. (2002): Evaluating Goodness-of-Fit Indexes for Testing Measurement Invariance. *Structural Equation Modeling, 9*(2), 233–255

Cools, W., De Martelaer, K., Samaey, C., & Andries, C. (2008). Movement skill assessment of typically developing preschool children: A review of seven movement skill assessment tools. *Journal of Sports Science and Medicine, 8*(2), 154–168.

Cools, W.; De Martelaer, K.; Vandaele, B.; Samaey, C., & Andries, C. (2010). Assessment of movement skill performance in preschool children: Convergent validity between MOT 4-6 and MABC. *Journal of Sports Science and Medicine, 9*, 597–604.

Davies, P. L., & Rose, J. D. (2000). Motor skills of typically developing adolescents: awkwardness or improvement. *Physical and Occupational Therapy in Pediatrics, 20*(1), 19–42.

Domínguez, P. & Espeso, E. (2003). Bases fisiológicas del entrenamiento de la fuerza con niños y adolescentes. *Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte, 3*(9), 61-68 http://cdeporte.rediris.es/revista/revista9/artfuerza.htm

Drenowatz, C., Hinterkörner, F. & Greier K. (2021). Physical Fitness and Motor Competence in Upper Austrian Elementary School Children-Study Protocol and Preliminary Findings of a State-Wide Fitness Testing Program. *Front Sports Act Living, 22*;3:635478. https:/doi.org/10.3389/fspor.2021.635478

Eather, N., Bull, A., Young, M. D., Barnes, A. T., Pollock, E. R., & Morgan, P. J. (2018). Fundamental movement skills: Where do girls fall short? A novel investigation of object-control skill execution in primary-school aged girls. *Preventive medicine reports*, *11*, 191–195. https://doi.org/10.1016/j.pmedr.2018.06.005

Elosua, P. (2005). Evaluación progresiva de la invarianza factorial entre las versiones original y adaptada de una escala de autoconcepto. *Psicothema, 17*, 356–362.

Fransen, J., Deprez, D., Pion, .J, Tallir, I. B., D'Hondt, E., Vaeyens, R., Lenoir, M., & Philippaerts R.M. (2014). Changes in Physical Fitness and Sports Participation Among Children With Different Levels of Motor Competence: A 2-Year Longitudinal Study. *Pediatric Exercise Science, 26*, 11–21.

Gallahue, D., & Ozmun, J. (2006). *Understanding Motor Development: infants, children, adolescents*. McGraw Hill.

García, J. M., Navarro, M., & Ruiz, J. A. (1996). *Bases teóricas del entrenamiento deportivo. Principios y aplicaciones*. Madrid: Gymnos.

Haywood, K. M., & Getchell, N. (2009). *Life Span Motor Development*. Human Kinetics (5th Edition)

Hardy, L. R., Tracie, P., Espinel, P., Zask, A., & Okely, A. D. (2012). Prevalence and Correlates of Low Fundamental Movement Skill Competency in Children. *Pediatrics. 130*, 390–398. https:/doi.org/10.1542/peds.2012-0345.

Henderson, S. E., & Sugden, D. (1992). Movement Assessment Battery for Children. Londres: Psychological Corporation. Henderson, S. E., Sugden, D. y Barnett, L. (2007). *Movement Assessment Battery for Children-second edition*. Londres: Pearson.

Hernández, J. L., Velázquez, R., Martínez, M. E., Garoz, I., & Tejero, C. M. (2011). Escala de Autoeficacia Motriz: propiedades psicométricas y resultados de su aplicación a la población escolar española. Revista de Psicología Del Deporte, 20(1), 13–28.

Holfelder, B., & Schott, R. (2014). Relationship of fundamental movement skills and physical activity in children and adolescents: a systematic review. *Psychology of Sport and Exercise, 15*, 382–391.

Kalaja S., Jaakkola T., Liukkonen J., & Watt A. (2010). The role of enjoyment, perceived competence, and fundamental movement skills as predictors of the physical activity engagement of Finnish physical education students. *Nordic Sport Studies 1*, 69–87.

Kiphard, E. J., & Schilling, F. (2007). Körperkoordinationstestfür Kinder 2, überarbeitete und ergänzte Aufgabe [Body coordination test for children 2, revised and supplemented task]. Weinham: Beltz test.

Lloret-Segura, S., Ferreres-Traver, A., Hernández-Baeza, A., & Tomás-Marco, I. (2014). El análisis factorial exploratorio de los ítems: una guía práctica, revisada y actualizada. *Anales de psicología, 30,* 1151–1169.

Logan, S.W., Scrabis-Fletcher, K., Modlesky, C., & Getchell, N. (2011). Preschool children with high body mass rank lower in motor proficiency. *Research Quarterly for Exercise and Sport, 82*(3), 442– 448. https:/doi.org/10.1080/02701367.2011.10599776

Lubans, D. R., Morgan, P. J., Cliff, D. P., Barnett, L. M., & Okely, A. D. (2010). Fundamental movement skills in children and adolescents: Review of associated health benefits. *Sports Medicine, 40*(12), 1019–1035. https:/doi.org/10.2165/11536850-000000000-00000

Luengo, C. (2007). Actividad físico-deportiva extraescolar en alumnos de primaria. *Revista Internacional de Medicina y Ciencias de la Actividad Física y del Deporte, 7*(27), 174- 184.

Luz, L. G. O., Cumming, S. P., Duarte, J. P., Valente-dos-Santos, J., Almeida, M. J., Machado-Rodrigues, A., Padez, C., Carmo, B. M., Santos, R., Seabra, A., & Coelho-E-Silva, M. J. (2016). 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

Luz, C., Rodrigues, L. P., Almeida, G., & Cordovil, R. (2016). Development and validation of a model of motor competence in children and adolescents. *Journal of Science and Medicine in Sport, 19*, 568–572. https:/doi.org/10.1016/j.jsams.2015.07.005. Epub 2015 Jul 10

Mathisen, G.E. (2016). Effects of school-based intervention program on motor performance skills. *School of Sport Sciences, UiT The Artic University of Norway*, *16*, 737–742. https:/doi.org/10.7752/jpes.2016.03119.

Matvienko, O., & Ahrabi-Fard, I. (2010). The Effects of a 4-Week After-School Program on Motor Skills and Fitness of Kindergarten and First-Grade Students. *American journal of Health Promotion, 24*, 299–303.

Milojević, A., & Stanković, V. (2010). Development of motor abilities of younger adolescents. *Facta Universitatis series Physical Education and Sport, 8*(2), 107–113.

Ministerio de Educación, Cultura y Deporte (2014). Real Decreto 1105/2014, de 26 de diciembre, por el que se establece el currículo básico de la Educación Secundaria Obligatoria y del Bachillerato. Boletín Oficial del Estado, 3 enero 2015.

McDonald, R., & Ho, M. (2002). Principles and practice in reporting structural equation analyses. *Psychological Methods, 7*(1), 64–82.

Meinel, K., y Schnabel, G. (2004), *Teoría del Movimiento*: *Motricidad Deportiva.* Stadium. (2ª ed,).

Menescardi, C., Villarrasa-Sapiña, I., Lander, N. & Estevan, I. (2022). Canadian Agility Movement Skill Assessment (CAMSA) in a Spanish Context: Evidences of Reliability and Validity. *Measurement in Physical Education and Exercise Science*. https:/doi.org/10.1080/1091367X.2021.2020794

Murgui, S., García, C., & García, A. (2016). Effect of sport practice on the relationship between motor skills, physical self-concept, and multidimensional self-concept. *Revista de Psicología Del Deporte, 25*(1), 19–25.

O'Connor, B. P. (2000). SPSS and SAS programs for determining the number of components using parallel analysis and Velicer's MAP test. *Behavior Research Methods Instrumentation, and Computers, 32,* 396–402.

Pérez-Camacho, R., Castillo Alvira, D., Herrero Román, F., Quevedo Jerez, K., Sánchez Díaz, S. y Yanci Irigoyen, J. (2021). Hábitos de actividad física y conductas sedentarias en escolares de Educación Primaria. *Revista Iberoamericana de Ciencias de la Actividad Física y el Deporte. 10*, 1, 59-85. https://doi.org/10.24310/riccafd.2021.v10i1.11470

Rodrigues, P. C.; Ribeiro, M.; Sousa, L.; Lopes, S., & Barros, R. (2019). Performance on the movement assessment battery for children: a systematic review about gender differences. *RICYDE. Revista internacional de ciencias del deporte. 55*(15), 71–87. https:/doi.org/10.5232/ricyde2019.05505

Robinson, L. E., Stodden, D. F., Barnett, L. M., Lopes, V. P., Logan, S. W., Rodrigues, L. P., & D'Hondt , E. (2015). Motor competence and its effect on positive developmental trajectories of health. *Sport Medicine,* 45, 1273–1284. https:/doi.org/10.1007/s40279-015-0351-6

Ruiz, L. M., Graupera, J. L., García, V., Arruza, J. A., Palomo, M., & Ramón, I. (2010). *Batería Muldimensional de la Competencia Motriz. Toledo: Laboratorio de Competencia Motriz*. Universidad de Castilla La Mancha.

Ruiz, L. M., & Palomo, M. (2018). Clumsiness and Motor Competence in Physical Education and Sport Pedagogy. In N. Llevot-Calvet (ed.) *Advanced Learning and Teaching Environments - Innovation, Contents and Methods* (pp 257–273). In techopen. https:/doi.org/10.5772/intechopen.70832.

Ruiz-Pérez, L. M., Barriopedro-Negro, M. I., Ramón-Otero. I., Palomo- Nieto, M., *Rioja-Collado, N., García-Coll, V., & Navia-Manzano,* J. A. (2017). Evaluar la Coordinación Motriz Global en Educación Secundaria: El Test Motor Sportcomp. *Revista Internacional de Ciencias del Deporte, 13*(49), 285–301. https:/doi.org/10.5232/ricyde

Ruiz, G., De Vicente, E., & Vegara, J. (2012). Comportamiento sedentario y niveles de actividad física en una muestra de estudiantes y trabajadores universitarios. *Journal of Sport and Health Research, 4*(1), 83–92.

Sánchez, F. (2002). *Didáctica de la Educación Física.* Madrid: Pearson Educación.

Santos, G. D., Guerra, P. H., Milani, S. A., Santos, A. B. D., Cattuzzo, M. T. & Ré, A. H. N. (2021). Sedentary behavior and motor competence in children and adolescents: a review. Rev. Saude Publica, 25, 55:57. https:/doi.org/10.11606/s1518-8787.2021055002917.

Schoemaker, M. M., & Kalverboer, A. F. (1994). Social and affective problems of children who are clumsy: How early do they begin? *Adapted Physical Activity Quarterly, 11*(2), 130–140.

Sgro, F., Quinto, A., Platania, F. & Lipoma, M. (2019). Assessing the impact of a physical education project based on games approach on the actual motor competence of primary school children. *Journal of Physical Education and Sport, 19,* 781-786. https:/doi.org/10.7752/jpes.2019.s3111

Sheehan, D. P. Lienhard, K. (2019). Gross motor proficiency and peak height Velocity in 10-14-year-old Canadian youth: a longitudinal study. *Measurement in Physical Education and Exercise Science, 23*(1), 89-98. https:/doi.org/10.1080/1091367X.2018.1525385

Stodden, D., Langendorfer, S., & Roberton, M.A. (2009). The association between motor skill competence and physical fitness in young adults. *Research Quarterly for Exercise and Sport,* 80, 223–229. https:/doi.org/10.1080/02701367.2009.10599556

Stodden, D. F. (2014). Current evidence on the associations between motor competence and aspects of health in youth: What do we know? *Science & Sports, 29*, S6. https:/doi.org/10.1016/j.scispo.2014.08.004

Stodden, D.F., Langendorfer, S., & Robertson, M. A. (2009). The association between motor skill competence and physical fitness in young adults. *Research Quarterly for Exercise and Sport, 80* (2), 223–229.

Ulrich, D.A. (2000). *TGMD-2: Test of Gross Motor Development*. Austin: Pro-ed (Second Edition) .

Utesch, T., Bardid, F., Büsch, D. & Strauss, B. (2019). The Relationship Between Motor Competence and Physical Fitness from Early Childhood to Early Adulthood: A Meta-Analysis. *Sports Med., 49*(4):541-551. https:/doi.org/10.1007/s40279-019-01068-y

Vandorpe, B., Vandendriessche, J.Lefevre, J., Pion, J., Vaeyens, R., Matthys, S., Philippaerts, R., & Lenoir, M. (2011). The Körperkoordinations Testfür Kinder: reference values and suitability for 6-12-year-old children in Flanders. *Scandinavian Journal of Medicine and Science in Sports,21* (3), 378–388. https:/doi.org/10.1111/j.1600-0838.2009.01067.x.

Vedul-Kjelsas, V., Stensdotter, A. K., Haga, M., & Sigmundsson, H. (2015). Physical fitness, self-perception and physical activity in children with different motor competence. *European Journal of Adapted Physical Activity, 8*, 45–57. https:/doi.org/10.5507/euj.2015.004

Vedul-Kjelsas, V., Sigmundsson, H., Stensdotter, A., & Haga, M. (2011). The relationship between motor competence, physical fitness and self-perception in children. *Child: care, health and development, 38,* 394–402. https:/doi.org/10.1111/j.1365-2214.2011.01275.x.

Table 1. Descriptives of Sportcomp Tests

	N	Min	Max	Skewness	Kurtosis	Boys		Girls		F	η^2
						Mean	SD	Mean	SD		
Flexibility	1026	0,00	42,00	0,120	-0,320	15,53	7,67	21,03	7,76	129,65***	,112
Medicinal balloon	1026	220	1150	0,800	0,401	639,2	146,1	492,1	84,4	370,88***	,266
Sit-ups	1026	6,00	47,00	0,208	0,558	25,66	5,25	21,92	4,82	139,48***	,120
Dynamometry	1026	13,0	65,00	1,021	1,038	32,29	9,22	25,59	5,10	197,39***	,162
Running up and back	1026	8,89	17,06	0,647	1,175	11,08	1,08	12,12	1,04	242,81***	,192
Equilibrium	1026	0,36	10,55	2,031	12,709	2,17	0,90	2,08	0,80	3,02	,003
3-meters over supports	1026	1,02	39,33	1,292	4,485	14,90	3,23	16,41	3,58	50,81***	,047
7m 1 leg	1026	1,04	4,47	0,936	2,355	2,16	0,38	2,43	0,37	134,48***	,116
7m feet together	1026	1,59	8,34	2,221	16,513	2,47	0,41	2,84	0,55	152,13***	,129
Lateral Jumps	1026	3,00	138,00	0,809	1,983	38,73	13,98	36,98	14,00	3,96*	,004

Note. *** p<.001; *p<.05

Table 2. Sportcomp Structure Factor: AFE and CFA

	AFE			CFA	
	Communality	Factor 1	Factor 2	Factor 1	Factor 2
Flexibility	,085	,031	-,097		
Medicinal balloon	,898	-,902	-,115	0.997	
Sit-ups	,452	-,318	-,467		0.647
Dynamometry	,734	-,859	,024	0.784	
Running up and back	,733	,364	,646		-0.856
Equilibrium	,039	-,021	-,158		
3-meters over supports	,467	,245	,508		-0.616
7m on 1 leg	,681	,274	,679		-0.802
7m with Feet Together	,641	,281	,641		-0.792
Lateral Jumps	,273	,159	-,506		
		r_{f1-f2}=.339		r_{f1-f2}=0.690	

Note. AFE: Exploratory factor analysis; CFA: Confirmatory factor analysis

Table 3. CFA SEM Model Comparison

	Chi-square	D.F.	P	CMIN/DF	RMSEA	CFI	TLI	Akaike
Model 1 One factor (10 tests)	425.935	35	0.0000	12,170	0.148	0.808	0.754	25886.804
Model 2 Three factors (10 tests. AFE_0)	137.634	32	0.0000	4,301	0.081	0.939	0.914	25102.329
Model 3 Two factor (8 tests. AFE_1)	118.800	19	0.0000	6,253	0.102	0.940	0.911	20857.468
Model 4. Two factors (7 tests)	47.748	13	0.0000	3,673	0.072	0.976	0.961	16817.065

Table 4. Factorial Invariance by Sex and Age

	Chi-square	d.f.	P	CMIN/DF	RMSEA	CFI	TLI	Akaike
				Sex				
Configural equivalence	98.753	26	.000	3,798	0.076	.975	.959	31067.328
Metric equivalence	109.576	31	.000	3,535	0.073	.973	.963	31068.150
Partial metric equivalence (test_9)	106.509	30	.000	3,550	0.073	.973	.963	31067.083
Partial metric equivalence (test_4)	105.350	30	.000	3,512	0.072	.974	.963	31065.925
Partial metric equivalence(test. 9 and 4)	102.258	29	.000	3,526	0.073	.975	.963	31064.833
Strict equivalence	451.723	38	.000	11,887	.151	.856	.841	31396.297
				Age				
Configural equivalence	139.484	53	.000	2,632	.084	.973	.956	31254.478
Metric equivalence	157.715	67	.000	2,354	.075	.972	.965	31242.709
Partial metric equivalence (test_9)	155.838	64	.000	2,435	.077	.972	.963	31246.832
Partial metric equivalence (test_4)	151.680	64	.000	2,370	.076	.973	.964	31242.674
Partial metric equivalence(test. 9 and 4)	149.831	61	.000	2,456	.078	.972	.962	31246.825
Strict equivalence	461.716	88	.000	5,247	.133	.884	.889	31504.710