Original Article

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Assessment of motor skills in 5-6 year old Italian children using the MABC-2: a preliminary study

Tiziana D'Isanto [1 ABDE], Sara Aliberti [1ACDE], Gaetano Raiola [2BDE], Francesca D'Elia [1CDE]

[1] Department of Human, Philosophical and Education Sciences, University of Salerno, Fisciano, Italy
[2] Faculty of Human, Educational and Sports Sciences, Pegaso University of Naples, Italy

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Abstract: The Movement Assessment Battery for Children - Second Edition (MABC-2) is a standardized test used to assess movement skills in children aged between 3-16 years old and to diagnose developmental coordination disorders (DCDs). Monitoring movement skills in children's is crucial to ensuring their proper physical development, as movement difficulties affect other areas of learning. In particular, it was interesting to investigate the role of gender and age in relation to different movement skills, as their development is influenced by genetic potential, in order which variables can help teachers to predict movement difficulties. The aim of the present study was to quantify the children's movement performance and to analyze the influence of gender, age and the gender x age interaction on movement performance. Methods: The sample consisted of 102 children aged between 5-6 years old from kindergartens. The MABC-2 was used to assess the children's movement performance, which comprised three sub-sections: manual skills, ball skills and balance skills. MANOVA was performed to assess the impact of gender, age and gender x age on performance. Chi Square was used to test differences in movement difficulties among gender. Results: The results showed a significant impact of both gender and age on performance individually, with a significant interaction effect of gender and age on performance. Conclusions: 12 children had several movement difficulties, while only 9 were at risk of DCDs, requiring ecological intervention.

Keywords: kindergartens; dexterity; balance; accuracy; testing

Corresponding author: Sara Aliberti, email: saaliberti@unisa.it

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INTRODUCTION

Movement difficulties in children's lives have increased dramatically in recent years. The COVID-19 pandemic and the subsequent restrictions, implemented to limit the spread of the virus, led to an unprecedented halt in physical and sports activities [1,2]. Early childhood education services and pre-schools were suspended, only to be resumed at first through distance learning (DaD), and at a later stage in presence, adopting prevention measures. However, DaD was not considered a fully inclusive modality, due to its dependence on socio-economic conditions and other aspects of the child [3]. Not all children had computers, tablets, and networks at their disposal to connect to distance learning lessons, as Italian National Institute of Statistics (ISTAT) data [4] states, thus falling behind their peers. Not to mention those with learning difficulties. Regarding the return to face-to-face teaching, in the early stages of the school's reopening, besides the compulsory wearing of masks, team games and the exchange of toys were discouraged, preferring static individual or outdoor activities [5, 6] to minimise opportunities of contact among children. However, pre-school children need corporeity and movement [7,8]: learning takes place through action, exploration, contact with objects, nature, art, territory, in a playful dimension [9,10].

The period of early childhood is considered the most important developmental phase of life. A child's early experiences lay the foundation for adult life. Several studies showed an increased levels of obesity [11], adherence to sedentary activities, a decreased physical activity and worsening sleep quality in children [12]; therefore, it becomes essential to protect children from sedentary behaviors and unhealthy habits. The World Health Organization (WHO) [13] issued new guidelines, which suggested that children and adolescents could achieve an average of 60 minutes of daily movement per week, and not at least one hour a day, as previously recommended. Lack of sufficient movement experience in early childhood can impair children's physical and cognitive development [14], over the learning of the other subjects. In the long run, the pandemic may have severe negative effects on the educational development of new generations [15]. Without specific interventions, any existing gaps may continue to widen.

Monitoring movement skills in children is crucial to ensure their proper development, as movement difficulties also affect other areas of learning [16]. Movement skills form the basis for daily living and participation in physical activities. Early childhood is the optimal stage for their development [17] through play-sport activities and social interactions. Reliable and valid instruments are needed to monitor and assess the development of movement skills [18]. The MABC-2 [19] is a standardized test used to assess movement skills in children aged between 3 - 16 years old and to diagnose DCDs. Previous studies addressed the validity of the instrument [20, 21]. Others focused on comparing children from various countries, such as China vs. the UK in children aged between 3-10 years old, revealing that Chinese children were generally better at manual dexterity and balance tasks, while British children at aiming and catching [22]. De Milander [23] stated that boys have a significantly higher prevalence of DCDs than girls. The study by Zoia et al. [24] explored differences in movement performance between Italian and British children and identified few differences between them. Finally, Faught et al. [25] found that body fat was able to negatively influence the MABC-2 balance score. Since this tool must be purchased, as its implementation consists of using the provided teaching kit, its dissemination is limited, especially regarding movement assessment related to age and gender, as movement development is also influenced by genetic potential [26]. Movement difficulties negatively affect children's participation in social and leisure activities, encouraging physical inactivity and sedentariness, which is very common among children today. Therefore, early detection of movement difficulties, through knowledge of the variables that may influence a children's movement development, is important to promote intervention strategies in both formal and informal settings.

The aim of the present study was to quantify the children's movement performance and to analyze the influence of gender, age and gender x age on movement performance. The research questions were:

1. How gender and age, both matched and disaggregated, affected movement skills?
2. What was the performance level in children aged between 5-6 years old?

MATERIAL AND METHODS

Participants

A convenience sample of 102 Italian children aged between 5-6 years was recruited from kindergartens. Children were assessed following the instructions provided in the MABC-2 examiner's manual by a sports kinesiologist previously trained. The inclu-sion criteria were children aged between 5-6 years old, who had received parental con-sent. Exclusion criteria were children with movement and cognitive difficulties. All children were tested within their own schools during the first half of the day in a classroom. Participants were guaranteed anonymity. No sensitive data were processed.

Data collection

All children were tested individually in a quiet area of the school, using the tasks for age group 1 (5-6 years old). Each child performed eight tasks divided into three categories:

a. Manual dexterity skills: threading 12 coins into a piggy bank (DM1); threading 12 cubes into a string (DM2); drawing a line on a predetermined design (DM3). For DM1 and DM2, the best score is the shortest possible time taken to complete the tests, while for DM3 by the fewest errors made in drawing the predetermined design.
b. Ball skills: catching a bag (distance 1.8 m; MeA1); throwing the bag into a carpet (distance 1.8 m; MeA2). For MeA1 and MeA2, the best score is given by the highest number of bags catches out of 10 possibilities and the highest number of successful centers out of 10 possibilities respectively.
c. Balance skills: balancing on one leg (max. 30 sec; E1); walking on a 4.5 m strip of tape (E2); jumping on 5 m mats with feet together (E3). For E1, the best result is the greatest number of seconds the subject can maintain balance up to a maximum of 30 seconds; for E2 the number of consecutive correct steps the child takes on a line drawn on the ground up to a maximum of 15; for E3 the number of consecutive jumps the child takes with two feet together up to a total of 5.

The materials used by the examiner are contained in Table 1.

Table 1. Instruments used for the MABC-2 tests

General materials	Chronometer Meter Colored adhesive tape (25 mm wide) Dark blue table mat
Specific materials	Age group 1 recording log with the route entered 1 red Berol fine tip pen 12 yellow coins 1 blue piggy bank 12 yellow cubes Red string Bag 6 floor mats (3 yellow, 2 blue, 1 blue with orange target)
Materials to be provided by the examiner	A smooth, neither too hard nor too slippery writing base Stopwatch Scissors to separate the courses and cut the tape

Statistical analysis

Descriptive statistics were used to describe all the relevant variables. The scores obtained were converted into standard scores using the MABC-2 manual, to classify children into three categories: no movement difficulties (score above 71 = green), at risk of movement difficulties (score between 63 and 71 = yellow), severe movement difficulties (score below 62 = red). The normality of the data was assessed using Kolmogorov–Smirnov test, while homogeneity of variances with Levene's test. After verifying all the other assumptions, MANOVA was performed to assess the effect of gender, age and the interaction of gender x age on MABC-2 sub-scores. Test scores were used as dependent variables. Significance was estimated using partial eta square (η^2), categorized as small (0.01), medium (0.06) and large (0.14 and higher) [27]. Chi Square (χ^2) was used to test the association between gender and DCDs classification. Significance was set at $p < 0.05$. Data analyses were performed using the Statistical Package for Social Science software (IBM SPSS Statistics for Windows, version 25.0. Armonk, NY).

Ethics committee

The study was conducted in accordance with the Declaration of Helsinki. Ethical review and approval were waived for this study because it was an educational research study that did not involve clinical treatment. No sensitive data were collected. Informed consent was obtained. All individuals involved in the study were guaranteed anonymity and were provided with complete and honest information about the content, purpose, and process of the research in an understandable way. No individual was forced to participate.

RESULTS

Table 2 showed the quantification of the movement difficulties according to dexterity, ball and balance skills, as well as the total score, to verify the presence of DCDs. Movement difficulties were found in 12 children, both male and female; 9 were at risk, while 81 did not present any movement difficulties. A detailed description is shown in Table 2.

Chi Square revealed a significant association between gender and DCDs classification (χ^2=12.69; p=0.002). It seemed that male children had more problems than females in terms of coordination. Descriptive statistics of MABC-2 tests by gender and age are shown in Table 3.

There was a statistically significant interaction effect between gender x age on the combined dependent variables, F(10, 89)=7.163, p=0.000; Wilks' Λ=0.554; η^2=0.4. Significant differences were found in DM1np test (p=0.005), DM3 (p=0.000), MeA1 (p=0.046), E1p (p=0.039) and E3 (p=0.007). As for gender, a statistically significance between all tests were found (p<0.05), as well as for age. A detailed description is shown in Table 4.

Table 2. Quantifying movement difficulties in 5-6 years old children

Gender	Age	Classification		
		Red (<62)	Yellow (63 - 71)	Green (>71)
Male	6	3	3	12
	5	6	6	24
Female	6	3	0	24
	5	0	0	21
Total		12	9	81

red, several DCDs; yellow, moderate DCDs; green, no DCDs

Table 3. Mean and standard deviation scores by age and gender for MABC-2 tests

Test	Gender	Age	M	SD	N
DM1 p threading 12 coins into a piggy bank with preferred hand	Female	5	22.43	1.63	21
		6	19.00	3.33	27
		Total	20.50	3.20	48
	Male	5	26.67	3.27	36
		6	21.17	3.17	18
		Total	24.83	4.14	54
DM1 np threading 12 coins into a piggy bank with non preferred hand	Female	5	24.00	0.95	21
		6	21.22	3.03	27
		Total	22.44	2.72	48
	Male	5	27.92	3.11	36
		6	21.83	3.22	18
		Total	25.89	4.25	54
DM2 threading 12 cubes into a string	Female	5	48.29	7.74	21
		6	38.44	5.06	27
		Total	42.75	8.00	48
	Male	5	61.33	12.98	36
		6	57.67	11.39	18
		Total	60.11	12.49	54
DM3 drawing a line on a predetermined design	Female	5	1.29	0.90	21
		6	2.00	1.07	27
		Total	1.69	1.06	48
	Male	5	1.67	1.39	36
		6	4.67	0.77	18
		Total	2.67	1.87	54
MeA1 catching a bag	Female	5	3.57	1.21	21
		6	4.67	1.07	27
		Total	4.19	1.25	48
	Male	5	4.17	1.23	36
		6	6.33	1.75	18
		Total	4.89	1.74	54
MeA2 throwing the bag into a carpet	Female	5	3.57	1.08	21
		6	5.22	1.34	27
		Total	4.50	1.47	48
	Male	5	4.17	1.16	36
		6	6.17	1.10	18
		Total	4.83	1.48	54
E1p balancing on one leg (max. 30 sec) with preferred leg	Female	5	9.71	3.04	21
		6	15.33	3.26	27
		Total	12.88	4.21	48
	Male	5	6.50	2.40	36
		6	9.67	2.89	18
		Total	7.56	2.96	54
E1np balancing on one leg (max. 30 sec) with non preferred leg	Female	5	7.29	3.18	21
		6	13.00	3.15	27
		Total	10.50	4.24	48
	Male	5	5.42	2.47	36
		6	8.83	3.00	18
		Total	6.56	3.09	54
E2 walking on a 4.5 m strip of tape	Female	5	8.71	0.90	21
		6	9.56	1.19	27
		Total	9.19	1.14	48
	Male	5	9.08	1.63	36
		6	11.00	1.68	18
		Total	9.72	1.87	54
E3 jumping on 5 m mats with feet together	Female	5	3.57	0.75	21
		6	4.33	0.83	27
		Total	4.00	0.88	48
	Male	5	4.42	0.65	36
		6	4.33	0.77	18
		Total	4.39	0.68	54

Table 4. MANOVA results for the analysis of the effect of gender, age and gender-age interaction for the scores of the M-ABC2 tests

Item	Gender			Age			Gender x age		
	F	p	η^2	F	p	η^2	F	p	η^2
DM1p	27.020	0.000	0.216	52.511	0.000	0.349	2.826	0.096	0.028
DM1np	15.493	0.000	0.137	59.340	0.000	0.377	8.258	0.005	0.078
DM2	60.926	0.000	0.383	10.675	0.001	0.098	2.231	0.139	0.022
DM3	43.596	0.000	0.308	64.755	0.000	0.398	24.523	0.000	0.200
MeA1	18.183	0.000	0.157	37.815	0.000	0.278	4.080	0.046	0.040
MeA2	10.072	0.002	0.093	56.626	0.000	0.366	0.518	0.473	0.005
E1p	57.279	0.000	0.369	56.057	0.000	0.364	4.368	0.039	0.043
E1np	25.743	0.000	0.208	58.917	0.000	0.375	3.730	0.056	0.037
E2	9.905	0.002	0.092	22.908	0.000	0.189	3.483	0.065	0.034
E3	7.733	0.007	0.073	4.984	0.028	0.048	7.733	0.007	0.073

DM1p, threading 12 coins into a piggy bank with preferred hand; DM1np, threading 12 coins into a piggy bank with non preferred hand; DM2, threading 12 cubes into a string; DM3, drawing a line on a predetermined design; MEA1, catching a bag; MEA2, throwing the bag into a carpet; E1p, balancing on one leg (max. 30 sec) with preferred leg; E1np, balancing on one leg (max. 30 sec) with non preferred leg; E2, walking on a 4.5 m strip of tape; E3, jumping on 5 m mats with feet together

DISCUSSION

The results of the present study identified twelve out of 102 Italian children aged 5-6 years with DCDs, while only nine were at risk. It seemed that male children had more problems than females in terms of general coordination. From the MANOVA analysis, both gender and age had a significant influence on the development of movement skills, whereas regarding the interaction of gender x age, the effect was only present for five skills.

Starting with the first research question, the results emphasized significant gender differences in movement scores. In the two manual dexterity tests girls scored better than boys, solving the task in significantly less time. On the drawing test, girls also scored better, making fewer mistakes. Thus, girls scored higher than boys in terms of manual dexterity (DM1, DM2, DM3). These findings were coherent with other studies [22, 28], as it appeared that females generally were more likely to engage in coordination-type activities. According to another study [29] it seemed that girls spent more time than boys involved in tasks requiring more skilled movements. The low level of manual skills in pre-school children were inversely correlated with the time spent in front of the screen, which increased during the COVID-19 pandemic given the physical-social restrictions [28]. For this reason, teachers should promote activities that aimed to improve dexterity. In the two ball tests, aiming and catching, males scored significantly higher than female. In this case, the best score was given by the number of successful attempts at both aiming and catching. This could be associated with the fact that males prefer to play more with the ball, as Amador-Ruiz also state [30]. Kokštejn et al. [29] also stated that 6-year-old boys scored better in aiming and catching than girls. Finally, only in the first balance test, consisted of maintaining the balanced position for as long as possible with both legs (max. 30 seconds), females significantly outperformed males. In this case, these results were partially in line with other studies, although in the other two tests, which consisted of walking along a strip and jumping with feet together, thus dynamical balance, males outperformed females. Regarding the differences in the movement performance test as a function of age, statistically significant differences were found in the dexterity tests, in which 6-years old children outperformed 5-years old children, except for DM3 in which 6-year male got the worst result. Regarding the aiming and catching tests, 6-years -old children also scored higher, as well as in all balance tests, especially the first one. As for the interaction across gender and age on movement performance, the result was

statistically significant. Gender and age matched influenced the following results tests: DM1np, DM3, MeA1, E1 and E3. The 6-year-old girls scored better than the other groups in the test consisting of threading 12 coins into a piggy bank with non-preferred hand, and the 5-year-old girls in drawing a line on a predetermined design. Six-year-old boys scored better on the catching a bag test. Finally, 6-year-old girls scored better in maintaining static balance with preferred leg, while 5-year-old boys in balancing on one leg and jumping on 5 m mats with feet together. Teachers should take these variables into consideration in planning the body and movement thematic core activities.

Regarding the second research question, the study showed that DCDs affected 20% of children considered. Individuals with low levels of movement competence have been shown to have worse levels of physical activity in adulthood [30] and have a higher risk of obesity. By comparing the results obtained with some of those present in the literature [22, 24], concerning the same age group, it seemed that our children scored worse. Lower scores were found in all tests of manual dexterity, aiming and catching, but especially in both static and dynamic balance. These could be consequences related to sedentary and inactive behaviors. Another cause could be the consequences of the COVID-19 pandemic and DAD. However, further studies are needed to verify this. An ecological intervention, following the guidelines of the MABC-2 manual, is necessary to improve movement competence, understood as the ability to perform different movement actions necessary for everyday activities [31]. Movement competence is a person's ability to perform different tasks, including fine and gross-movement coordination that are necessary for everyday activities [32]. The lack of adequate acquisition of movement competence is linked to a 'competence barrier' [33], in which individuals with low levels of movement competence demonstrate worse levels of physical activity in adulthood [31]. To overcome this barrier, teamwork is required, involving different figures, including teachers, parents, but above all the kinesiologist, a graduate in exercise and sports sciences. His task is to plan, design and periodise the intervention from the physical point of view, and to be the child's main point of reference. To do their job best, quantitative evaluation must be combined with qualitative one, hence the observation grids in the M-ABC2 manual, which in this work are not dealt with. The aim of the intervention must be to improve the child's movement skills, so that even with difficulties, the child can participate in everyday life activities and use movement as a learning channel. The intervention must aim at the enhancement of the individual, and not at its normalisation. The result is the interaction between child, task and environment.

This study had several limitations, such as the convenience sampling, which may lead to limited generalizability of results, and lack of demographic variables, due to logistic and timing reasons. Nevertheless, the tool was valid and reliable. For future studies, it is recommended to improve the sample and collect socio-demographic variables. The issue of the consequences of COVID-19 on the development of movement skills needs to be further investigated, considering the negative effects especially on cognitive functions, which can be improved through physical exercise [34-38]. In addition, experimental protocols could be implemented in children classified as 'at risk for movement difficulties'. Differences in movement skills between boys and girls should be taken into consideration to identify them at an early stage and adopt preventive interventions.

CONCLUSION

The results showed that out of 102 Italian children aged 5-6 years, twelve had severe coordination problems, while only nine were at risk. Movement difficulties predominantly affected the male gender. Comparing the results with the literature, our sample had worse scores than the children of the same age tested previously. Differences between males and females in the different sub-tests were found, which may help teachers prevent movement difficulties through prevention. Specifically, females had higher levels of manual dexterity, while males had higher performance in aiming and catching. In terms of balance, females had higher performance in static balance, while males had higher

performance in jumping and dynamic balance. As for age, 6-year-olds had higher scores in all tests except drawing. This study can be a starting point that emphasizes the importance of monitoring the level of movement skills from preschool onwards.

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