

# The Movement Assessment Battery for Children Second Edition in Ages 3 to 6 Years: A Cross-Cultural Comparison for Children in Taiwan

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## Abstract

**Objective.** The Movement Assessment Battery for Children-2 (MABC-2) is a popular assessment of children's motor skills in both Western and Eastern countries. Since children's motor skills are strongly influenced by the sociocultural context, it is essential to specifically examine the applicability of the MABC-2 in different cultures. The performance on the MABC-2 age band 1 of children in Taiwan was compared with the standardized sample from the United Kingdom. The sex differences in the performance on the MABC-2 were also investigated.

**Methods.** Children aged 3 to 6 years were recruited and categorized into 4 age groups. The researchers assessed the children with the MABC-2 age band 1, containing 8 tasks categorized into 3 components: manual dexterity, aiming and catching, and balance. Z tests and effect sizes were used to examine the cultural differences in the 3 components and in the total scale of the MABC-2. Independent *t* tests were used to check for sex differences in the MABC-2.

**Results.** Data on 615 children with a mean age of 4.95 years ( $SD = 0.97$ ) were collected. Clinically significant differences (effect size  $> 0.5$ ) were found in 2 components and the total scale of the MABC-2 across most age groups. Children in Taiwan performed better on manual dexterity, balance, and the total scale. Marginally clinically significant differences (absolute effect size  $> 0.4$ ) were found in the aiming and catching component for the children aged 3 and 6 years old; children in Taiwan scored lower on aiming and catching than did children in the United Kingdom. Girls had significantly higher scores on manual dexterity, balance, and the total scale, while boys had significantly higher scores on aiming and catching.

**Conclusions.** Cultural and sex differences exist in the MABC-2. Constructing a norm for children in Taiwan of different sex and modification of the items are suggested for application of the MABC-2 in Taiwan.

**Keywords:** Children, Cultural Comparison, Movement Assessment Battery for Children-2 (MABC-2)

## Introduction

Motor skills are critical for children to execute daily activities and perform schoolwork. Children having problems in gross and fine motor skills often fail to effectively get dressed, manipulate stationery, and play on the playground. Moreover, accumulated frustration from participating in physical activities may negatively impact children's self-esteem and self-competence,<sup>1,2</sup> and it may also hinder their social participation and interpersonal relationships.<sup>3</sup> As a result, it is essential to identify motor skill problems to help teachers, clinicians, and parents implement corresponding interventions or provide appropriate resources.

The Movement Assessment Battery for Children–Second edition (MABC-2) is a common assessment of motor skills in children from 3 to 16 years (including 3 age bands).<sup>4</sup> It has been widely used in Western and Eastern countries for both clinical and research purposes,<sup>5–7</sup> including in Taiwan. Most countries identify impairments of motor skills by adopting the norms of the standardization sample from the UK. To adopt these norms, it is essential to consider the cultural validity of the MABC-2. Cultural validity refers to the suitability of applying the norms of one culture to a different culture. The sociocultural context where a child lives may place certain demands on motor behaviors and thus facilitate some aspects of motor skills.<sup>8</sup> That is, children's performance on motor tasks may rely on their experiences in previous similar physical activities. A previous review discussed the cross-cultural validity of motor assessment tools.<sup>9</sup> It reported that 13 studies found significant differences between cultural contexts and the normative sample. It follows that the issue of culture is important when norms are applied in different sociocultural contexts.

Several studies have examined the suitability of applying the standardization norms of the first edition of the MABC (MABC) or the second edition (MABC-2) to eastern countries. For the MABC, Chow found that, although the test content is suitable for children in Hong Kong, cultural differences between Hong Kong and the United States existed on several test items.<sup>10</sup> Chinese children performed better on the manual dexterity (MD) and balance (BAL) components, while American children performed better on the aiming and catching (AC) component. Another study by Chow et al compared the MABC scores among 799 children from Hong Kong, Taiwan and the United States.<sup>11</sup> The study showed that cross-cultural differences were significant when all items were examined together. They also found a ceiling effect on the item of “walking along a line with heels raised” in Chinese children. Since cross-cultural differences exist in the MABC, there is a high possibility that the MABC-2 has cultural differences between Western and Eastern cultures.

For the MABC-2, Hirata et al and Kita et al respectively examined the applicability of the MABC-2 age band 1 and age band 2 in Japanese children.<sup>12,13</sup> Consistent with previous studies using the MABC, both studies reported that the scores of Japanese children on MD and BAL were superior to those of the normative data. Moreover, the girls' scores on BAL were higher than those of the boys in both age bands, and the girls also had higher scores on the MD component in the MABC-2 age band 1. Generally, the 2 studies also found cultural differences in motor skills between the UK and Japan.

However, 2 issues regarding the 2 studies should be addressed. First, they did not examine the differences in item level or detail, eg, the ceiling and floor effects of each item and the extent of the difference. Therefore, the items that need further adjustment remain unknown. Second, the sample sizes were small, restricting the generalizability of the studies. The 2 studies recruited 252 and 132 children categorized into 4 age groups in age band 1, respectively. The number of children in each group ranged from 31 to 91 in the study by Hirata, et al and from 28 to 44 in the study by Kita, et al<sup>12,13</sup> A larger sample size in each age group or more studies are suggested to cross-validate the results of the 2 studies.

In the present study, we chose the MABC-2 age band 1 (children aged 3–6 years) for the preliminary investigation. We compared the performance of children in Taiwan on the MABC-2 age band 1 with the standardized sample from the UK. We aimed to examine the cultural differences between the 2 cultures to ensure the applicability of the MABC-2 in eastern cultures. Moreover, because sex differences in the MABC-2 were found in previous studies,<sup>14</sup> sex differences in the MABC-2 age band 1 were also investigated in this study.

## Methods

### Participants

The data were drawn from an ongoing large project entitled “An Artificial Intelligence System for Assessing Gross Motor and Fine Motor, Handwriting, Attention and Emotion in Children with Developmental Delay.”<sup>14</sup> The inclusion criteria of the participants in the project at initial evaluation were (1) age of 1 to 6 years; (2) ability to follow a researcher's instructions; and (3) caregiver's consent to record video during the evaluation. The diagnosis of developmental conditions was reported by their caregivers on a basic information questionnaire. No additional criteria were set for the developmental conditions. However, according to the manual of the MABC-2, the MABC-2 is not suitable for application to children with severe physical disabilities (eg, inability to walk). Therefore, children with severe physical disabilities (eg, a diagnosis of cerebral palsy) were excluded from the analysis.

Because this project has been ongoing for 3 years, some children had been evaluated 2 to 4 times (for the follow-up). The intervals between each evaluation were 6 months for children recruited from a rehabilitation clinic and 1 year for children recruited from kindergartens. The data of children aged 3 to 6 years with and without developmental conditions during the 3 years were selected for analysis in this study.

Each child participated in 2 separate sessions as part of the project. One session involved engaging in activities designed by our research team, while the other session consisted of standard assessments of motor and visual-motor integration. The MABC-2 assessment was administered in the session consisting of standardized assessments. The 2 sessions were conducted within a 2-week period. Due to the distinct content and nature of the 2 sessions, they were considered independent of each other.

None of the follow-up data were in the same age norm as the previous set (ie, the follow-up data were not analyzed together with the previous set). Therefore, we viewed all the follow-up data as independent data for comparison with the UK norms. The ongoing large project was approved by the

Institutional Review Boards of 2 hospitals respectively in the cities of Kaohsiung and Taipei in Taiwan.

## Measures

### Movement Assessment Battery for Children-2 (MABC-2)

The MABC-2 is an assessment for motor skills in children aged 3 to 16 years.<sup>4</sup> It contains 3 age bands: age band 1, 3 to 6 years; age band 2, 7 to 10 years; and age band 3, 11 to 16 years. Each age band contains 8 tasks categorized into 3 components: manual dexterity (MD), aiming and catching (AC), and balance (BAL). The raw scores of the 8 tasks are transformed into standardized scores. For each component, the standardized scores of the tasks are summed up to form the component scores. The component scores and the sum of the component scores (the total score of the total scale) are transformed into standard scores/total standard scores and percentiles. The standard scores, total standard scores, and percentiles are further used to diagnose children with or without significant impairment in motor skills. Percentiles < 5% indicate significant impairments in motor skills. The MABC-2 is especially useful to identify children with developmental coordination disorder (ie, a disorder of significant deficits in motor skills). The psychometric properties of the MABC-2 have been examined in Chinese children.<sup>15,16</sup>

### Procedures

Before the formal administration of the MABC-2, all researchers received rigorous training on assessing the MABC-2 to ensure inter-rater reliability. All researchers practiced administering the MABC-2 on 2 to 3 children under the supervision of the first author of this study. The first author is an occupational therapist and has routinely used the MABC-2 for clinical evaluation. We also executed a pilot study, for which 5 children were recruited. In the pilot study, all researchers achieved 80–90% consensus on item scoring.

Each child attended 2 sessions, and the MABC-2 was assessed in one of the sessions. The researchers assessed the children with the MABC-2 one by one. It took 30 to 40 minutes to complete the MABC-2.

### Statistical Analyses

Descriptive data were used to characterize the demographic variables of the participants, and the mean and SD of the standard scores were calculated for the 3 component scores and total standard scores of the MABC-2.

Children were categorized into 4 age groups for the comparison. The  $z$  tests and effect sizes (Cohen  $d$ ) were used to examine differences in the standard scores of the 3 components and the total standard scores between the samples from Taiwan and the UK. Significant differences were set at 2-tailed  $p < 0.5$ . As for effect size, Cohen  $d > 0.2$ , 0.5, and 0.8 indicated small, moderate, and large effect sizes.<sup>17</sup> Moreover, in clinical practice, Cohen  $d > 0.5$  with a significant  $z$  test represents a clinically significant difference.<sup>18</sup>

To examine the floor and ceiling effects of the items, the percentages of the children achieving the highest or lowest scores on each item were calculated. Percentages larger than 20% indicated a significant floor or ceiling effect. Moreover, to identify the proportion of children identified as having significant impairments in motor skills, the percentages of

children lower than 5 on the 3 components and the total scale were calculated.

To examine the sex differences, independent  $t$  tests were used to compare the standard scores of the 3 components and the total scale between boys and girls. Additionally, our study included both children with and without developmental conditions and recruited samples from kindergartens and a rehabilitation clinic. We conducted further analyses to examine age and score differences in the 3 components as well as the total scale between children with and without developmental conditions and between children from kindergartens and those from the rehabilitation clinic by independent  $t$  test. Statistical analyses were conducted in IBM SPSS 20.

### Role of the Funding Source

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## Results

### Characteristics of the Participants

Data of 615 children were used in our study, and about half (55.9%) were boys. There was no age difference between the girls and the boys ( $P = 0.921$ ). Children were recruited across western Taiwan, including 5 cities spanning urban and suburban areas. Furthermore, around 18% of the children had been diagnosed with at least 1 developmental-related condition, such as developmental delay or autism spectrum disorder. Only a small percentage of the children (1%;  $n = 6$ ) attended special education classes or special education schools/developmental centres; however, these children were able to comprehend and follow the instructions provided by the researchers. Among the 615 children, 15.9% ( $n = 98$ ) were recruited from the rehabilitation clinic. The characteristics of the participants are shown in Table 1.

### Comparison of Performance on the MABC-2 Between Children in Taiwan and the United Kingdom

Table 2 lists the mean standard scores, the standard deviation, the  $z$  test values, and the effect sizes of the 3 components and the total scale of the MABC-2 in children in Taiwan. Except the total scale in age group 6, the standard scores on MD, BAL and the total scale achieved clinically significant differences between children in Taiwan and those in the UK across all age groups. The effect size ranged from 0.55 to 1.08. Children in Taiwan performed better on MD and BAL and on the total scale. In contrast, although not a clinically significant difference, children in Taiwan scored lower on the AC than did children in the UK.

Table 3 presents the floor and ceiling effects of the 8 items. No floor effects were found in the 8 items. Significant ceiling effects were found in the items of “drawing trails”, “one-leg balance (better leg)”, “one-leg balance (the other leg)”, “walking heel raised” and “jumping on mats”. Table 4 shows the percentages of children having significant impairments on the 3 components and the total scale. Among the 3 components and the total scale, AC had the most children identified as having significant impairments (9.5%–18.8%).

**Table 1.** Demographic Variables of the Participants (N = 615)

Variables	Statistics
Age, y: mean (SD)	4.95 (0.97)
Sex (male): n (%)	344 (55.9)
Diagnosis: n (%)	
Developmental delay	79 (12.8)
Autism spectrum disorder	14 (2.3)
Attention-deficit hyperactivity disorder	23 (3.7)
Cognitive impairments	5 (0.8)
Chromosomal abnormalities	5 (0.8)
Others (eg, epilepsy and emotional problems)	10 (2.9)
Region: n (%)	
Taipei (Northern Taiwan)	74 (12.0)
New Taipei city (Northern Taiwan)	98 (15.9)
Taichung (Central Taiwan)	79 (12.8)
Tainan (Southern Taiwan)	297 (48.3)
Kaohsiung (Southern Taiwan)	67 (10.9)

The Figure illustrates the differences in the scores of the 3 components and the total scale between the boys and the girls. Significant differences existed in the 3 components and total scores. The girls had higher scores on MD, BAL and the total score, while the boys had higher scores on AC.

Apart from the age differences between children with and without developmental conditions, the results showed significant differences in the age, the 3 subscales, and the total scale between children with and without developmental conditions, as well as between children recruited from kindergartens and those from the rehabilitation clinic. When comparing children with and without developmental conditions, no significant age difference was found between the 2 groups. Moreover, children without developmental conditions exhibited higher scores on all 3 subscales and the total scale, as indicated in Table 5. In terms of children recruited from kindergartens and the rehabilitation clinic, a significant age difference was observed, with children in the rehabilitation sample being older. Additionally, significantly lower scores were found in the 3 subscales and the total scale of the MABC-2 for children from the rehabilitation clinic.

## Discussion

This study compared the performance of the MABC-2 of children in Taiwan with the standardized sample from the UK to examine the cultural differences and the applicability of the MABC-2 in an eastern culture. The results led to 3 main findings. First, significant differences between children in Taiwan and their counterparts in the UK exist in the 3 components of the MABC-2 across most age groups. Second, ceiling effects exist in several items in children in Taiwan, such as drawing trails and jumping on mats. Third, the performances on the 3 components were significantly different between boys and girls. The results of our study indicate that, when assessing children's motor skills, differences in culture and sex should be considered.

Compared to those of the children in the UK, the scores on MD and the BAL were significantly higher in children in Taiwan in most of the age groups. The results were consistent with previous studies conducted in Asian countries.<sup>11–13</sup> The results were reasonable for 2 reasons. First, children in Eastern

cultures have more experience in executing fine motor tasks or start manipulating tools earlier, such as when drawing, using chopsticks, using spoons, and writing. Chui et al reported that children in Hong Kong had better performance on subtests of visual-motor control and upper limb speed and dexterity.<sup>19</sup> They stated that many children in Hong Kong begin to write at the age of 3 and use chopsticks at the age of 2. In addition, handwriting-related tasks are common in preschool life. These situations can also be seen in children in Taiwan at preschool age. As a result, the frequent exposure to fine motor tasks may facilitate the development of fine motor skills.

Second, the gross motor activities that children in Taiwan often engage in place high demands on balance skills. Taiwan is a country with a high population density. The spaces for gross motor activity are thus limited. Children in Taiwan may tend to pursue activities requiring less space, such as dancing, rollerblading, and riding bicycles or push bikes. The above activities facilitate children's balance skills. This possibility is supported by the results of Huang et al's study.<sup>20</sup> They investigated the physical activities of Taiwanese school-aged children from urban and rural areas. The physical activities that children most often engaged in were walking, jogging, stair-climbing, and chasing games.

The above findings are also supported by the ceiling effects in the items of "drawing trails", "one leg balance", "walking heel raised" and "jumping on mats". Our study found that most of the children aged 4 to 6 years achieved the highest standard scores on these items, especially on the item of "drawing trails". The results on the ceiling effects also indicate that those items are too easy for children in Taiwan. As a result, the differentiation ability of those items could be restricted. Future studies are suggested to revise the items for better identification of motor skills in Asian children.

In contrast, although the observed differences were not clinically significant, scores on the AC component still showed a significant deviation from the UK normative sample. Similar findings were reported in a study by Ruiz et al,<sup>21</sup> where they discovered significant differences in 2-handed catching performance between a Japanese sample and an American sample. The American children performed better than their Japanese counterparts. Additionally, Yang et al conducted a

**Table 2.** Comparison of the Scale Standard Scores and the Total Standard Scores With the United Kingdom Sample (N = 615)

Age Group	3			4			5			6		
	n	Mean (SD)	Z Test (P)	Effect Size	n	Mean (SD)	Z Test (P)	Effect Size	n	Mean (SD)	Z Test (P)	Effect Size
Manual dexterity	115	12.01 (3.38)	7.18 (<.001)	0.67	188	11.91 (2.95)	8.73 (<.001)	0.64	207	11.70 (3.27)	8.15 (<.001)	0.57
Aiming and catching	82	8.52 (2.75)	-4.47 (<.001)	-0.49	137	8.88 (2.49)	-4.37 (<.001)	-0.37	156	9.60 (3.00)	-1.67 (1.10)	-0.13
Balance	82	12.78 (4.27)	8.39 (<.001)	0.93	137	13.24 (3.77)	12.64 (<.001)	1.08	156	13.03 (3.39)	12.61 (<.001)	1.01
Total scale	82	11.65 (3.88)	4.98 (<.001)	0.55	137	11.88 (2.98)	7.33 (<.001)	0.63	156	11.90 (3.26)	7.91 (<.001)	0.63
												0.42

study supporting our results, focusing on the challenging items of the Test of Gross Motor Development, Second Edition (TGMD-2) and the Bruininks–Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) for Taiwanese children.<sup>22</sup> Their findings indicated that around 70 percent of children aged 48 to 59 months were unable to push a ball with their fingertips in the TGMD-2, and approximately 65 percent of children aged 48 to 59 months struggled to maintain control of a ball for consecutive bounces without needing to move their feet to retrieve it. Similarly, on the BOT-2, all children faced difficulties in dribbling a ball with alternating hands. As a result, they suggested that preschool teachers should design loosely structured ball activities that children can enjoy without formal instruction. One possible explanation for the lack of ball skills could be attributed to Taiwanese children having less exposure to ball-related activities. Given the limited living space and high population density in Taiwan, children may have fewer opportunities to engage in ball activities that involve throwing and catching skills, such as baseball and Frisbee, especially in urban areas. Another contributing factor could be the long working hours of parents, which leave them with limited time to take their children outdoors to engage in ball sports.

Comparing the motor performance between boys and girls, the girls performed better on MD and BAL, while the boys performed better on AC. The results were partly consistent with the studies by Hirata et al and Kita et al.<sup>12,13</sup> In their studies, girls scored higher than boys on the BAL component. Moreover, a longitudinal study by Barnett et al. reported that boys outperformed girls in object control skills (eg, kicking, throwing, and catching balls).<sup>23</sup> Based on the results of our study, the norms of the MABC-2 should be separated by sex.

It is important to note that our sample consisted of children with disabilities, and we recruited participants from both kindergartens and a rehabilitation clinic. Approximately 18% of the children in our study had a developmental-related diagnosis such as autism and attention deficit hyperactivity disorder. While significant score differences were observed between children with and without developmental conditions and between those recruited from kindergartens and the rehabilitation clinic, consistent score trends were found across all conditions. Specifically, the mean scores were higher than the mean standard scores in the components of MD, BAL, and the total scale, while lower mean scores were observed in the component of AC. In addition, it is worth mentioning that almost all the children in our study attended regular classes in general kindergartens or schools. Only a small percentage (1%) of the recruited children attended special education classes or specialized schools/developmental centres but were still able to follow the instructions provided by the researchers. Additionally, it is important to note that the manual of the MABC-2 does not list these diagnoses as exclusion criteria. Considering the objective of our study, which aimed to examine the applicability of norm scores developed in the UK, it was appropriate to include data from children with developmental conditions in our analyses.

Two limitations were noted in our study. First, to avoid small sample sizes in each age group, we combined the data of boys and girls for the comparison with the UK sample. Considering the differences in motor performance between boys and girls, future studies should split the data into boys and girls in each age group for further analysis. Second,

**Table 3.** The Floor and Ceiling Effects of Each Item of the MABC-2 (N = 615)<sup>a</sup>

Age Group	3		4		5		6	
	Floor n/n1 (%)	Ceiling n/n1 (%)	Floor n/n1 (%)	Ceiling n/n1 (%)	Floor n/n1 (%)	Ceiling n/n1 (%)	Floor n/n1 (%)	Ceiling n/n1 (%)
Posting coins (preferred hand)	3/115 (2.61)	3/115 (2.61)	4/188 (2.13)	1/188 (0.53)	2/207 (0.97)	0/207 (0.00)	1/105 (0.95)	5/105 (4.76)
Posting coins (non-preferred hand)	6/115 (5.22)	7/115 (6.09)	2/188 (1.06)	10/188 (5.32)	9/207 (4.35)	0/207 (0.00)	4/105 (3.81)	0/105 (0.00)
Threading beads	2/115 (1.74)	7/115 (6.09)	2/188 (1.06)	18/188 (9.57)	1/207 (0.48)	0/207 (0.00)	1/105 (0.95)	0/105 (0.00)
Drawing trail	5/115 (4.35)	13/115 (11.30)	3/188 (1.60)	44/188 (23.40)	10/207 (4.83)	169/207 (81.6)	7/105 (6.67)	87/105 (82.86)
Catching bean bags	2/82 (2.45)	1/82 (1.22)	10/137 (7.30)	3/137 (2.19)	6/156 (3.85)	10/156 (6.41)	3/85 (3.53)	11/85 (12.94)
Throwing bean bags	16/82 (19.51)	0/82 (0.00)	6/137 (4.38)	1/137 (0.73)	3/156 (1.92)	0/156 (0.00)	1/85 (1.18)	1/85 (1.18)
One-leg balance (better leg)	2/82 (2.44)	16/82 (19.51)	1/137 (0.73)	49/137 (35.77)	0/156 (0.00)	115/156 (73.72)	0/85 (0.00)	67/85 (78.82)
One-leg balance (the other leg)	3/82 (3.66)	15/82 (18.29)	1/137 (0.73)	25/137 (18.25)	0/156 (0.00)	67/156 (42.95)	0/85 (0.00)	49/85 (57.65)
Walking heel raised	6/82 (7.32)	30/82 (36.59)	0/137 (0.00)	101/137 (73.72)	0/156 (0.00)	132/156 (84.62)	4/85 (4.71)	75/85 (88.24)
Jumping on mats	1/82 (1.22)	56/82 (68.29)	5/137 (2.19)	111/137 (81.02)	0/156 (0.00)	128/156 (82.05)	1/85 (1.18)	74/85 (87.06)

<sup>a</sup>MABC-2 = The Movement Assessment Battery for Children—Second edition; n1 = the number of children administered with the item.

**Table 4.** The Percentage of Children Identified as Having Significant Impairment in Each Age Group

Age Group	Manual Dexterity (n, %)	Aiming and Catching (n, %)	Balance (n, %)	Total Scale (n, %)
3	5 (4.3)	11 (13.4)	4 (4.9)	4 (4.9)
4	6 (3.2)	13 (9.5)	3 (2.2)	3 (2.2)
5	12 (5.8)	15 (9.6)	4 (2.6)	10 (6.4)
6	5 (4.8)	16 (18.8)	2 (2.4)	5 (5.9)

**Table 5.** The Age and Score Differences in the 3 Components and Total Scale of the MABC-2 Between Children With and Without Developmental Conditions<sup>a</sup>

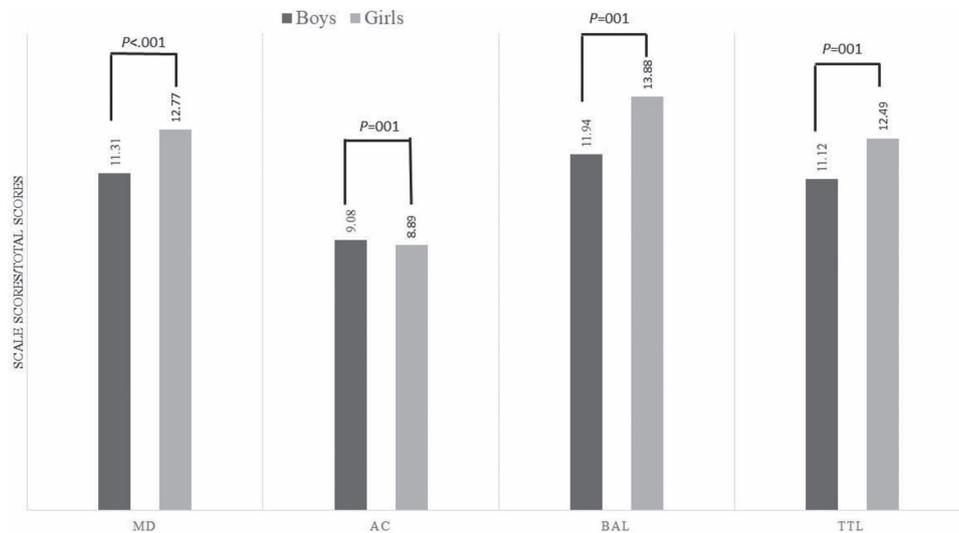
Variables	Children Without Developmental Conditions Mean (SD)	Children With Developmental Conditions Mean (SD)	<i>P</i>	Kindergarten Sample Mean (SD)	Rehabilitation Sample Mean (SD)	<i>P</i>
Age	58.99 (11.59)	61.35 (12.02)	.055	58.90 (11.48)	62.14 (12.51)	.012
Manual dexterity	12.49 (2.89)	8.23 (3.06)	< .001	12.32 (3.02)	10.06 (3.69)	< .001
Aiming and catching	9.15 (2.81)	8.23 (3.06)	.01	9.14 (2.76)	8.29 (3.26)	.017
Balance	13.25 (3.39)	10.56 (3.83)	.01	13.16 (3.45)	10.97 (3.85)	< .001
Total scale	12.21 (2.92)	9.35 (3.90)	< .001	12.10 (3.09)	9.90 (3.63)	< .001

<sup>a</sup>MABC-2 = The Movement Assessment Battery for Children—Second edition

the sample recruited in our study was drawn exclusively from urban and suburban areas in western Taiwan. Performances on motor skills may differ slightly between Western and Eastern countries because eastern Taiwan is less urbanized. Accordingly, future studies are advised to recruit larger sample sizes and recruit children from both western and eastern Taiwan.

## Conclusion

Cultural and sex differences were found in the MABC-2 age band 1. Moreover, 4 items of the MABC-2 had ceiling effects in children in Taiwan. The results indicate that the construction of norms for children in Taiwan of different sex and modification of the items could better identify motor skill problems and interpret the motor performance of children in Taiwan.



**Figure.** Standard scores for each component and the total standard scores for boys and girls. AC = aiming and catching; BAL = balance; MD = manual dexterity; TTL = total scale.

## Author Contributions

Chien-Yu Huang (Conceptualization-Equal, Formal analysis-Equal, Investigation-Equal, Methodology-Equal, Resources-Equal, Supervision-Equal, Writing – original draft-Equal, Writing – review & editing-Equal), Tzu-Yun Huang (Data curation-Equal, Investigation-Equal, Project administration-Equal, Writing – original draft-Equal, Writing – review & editing-Equal), Chia-Lin Koh (Formal analysis-Equal, Investigation-Equal, Methodology-Equal, Validation-Equal, Writing – original draft-Equal, Writing – review & editing-Equal), Yen-Ting Yu (Formal analysis-Equal, Investigation-Equal, Methodology-Equal, Project administration-Equal, Writing – original draft-Equal, Writing – review & editing-Equal), Kuan-Lin Chen (Conceptualization-Equal, Formal analysis-Equal, Investigation-Equal, Methodology-Equal, Supervision-Equal, Writing – original draft-Equal, Writing – review & editing-Equal).

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## Ethics Approval

This study was approved by the institutional review boards of 2 hospitals in the cities of Kaohsiung and Taipei in Taiwan.

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## Data Availability

The data that support the findings of this study are available from the first author, CYH, upon reasonable request.

## Disclosure

The authors completed the ICMJE Form for Disclosure of Potential Conflicts of Interest and reported no conflicts of interest.

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