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Normative reference values for Obstacles Test and Curb Test and their correlation with demographic characteristics: a cross-sectional study in Saudi children

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The Obstacles Test and Curb Test have been used to measure gait speed and functional balance in adults. Recently, they have been modified for use in children but the normative values have not been established. This requires correlating the sex, age, height, weight, and BMI% of children with the test results and developing prediction equations. In this cross-sectional study, the Obstacles Test and Curb Test were administered to a convenience sample of 240 typically developing children aged 6–11 years. The factors associated with the time to complete each test were studied and prediction equations were established. The completion times were 5.27 ± 0.81 s for the Obstacles Test and 2.82 ± 0.45 s for the Curb Test. The Obstacles Test showed a fair negative relationship with height (Pearson's $r=-0.41$, $P<0.001$), age ($r=-0.35$, $P<0.001$), and weight ($r=-0.32$, $P<0.05$). The Curb Test also had fair negative correlations with height ($r=-0.42$, $P<0.001$), age ($r=-0.39$, $P<0.001$), and weight ($r=-0.31$, $P<0.001$). Both tests showed poor correlations with the sex [eta (η) = 0.15 and 0.12, respectively]. Nonetheless, age and sex emerged as the main predictors of both test scores, accounting for 14% and 17% of the total variance in the Obstacles Test and Curb Test times, respectively. Normative values and prediction equations for both tests in typically developing children may be used for individual comparisons and in clinical research for the evaluation of interventions targeting disabled children. *International Journal of Rehabilitation Research* 46: 70–76 Copyright © 2022 The Author(s). Published by Wolters Kluwer Health, Inc.

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Introduction

Walking is an activity that involves several components, such as stepping ability, gait speed, dynamic balance, and the ability to adjust one's performance to meet environmental demands [1,2]. Tools that measure walking performance exist, but few are responsive with highly functional children or represent walking in the community [1,3–5]. Timed walking tests are global indicators of the components needed for walking [1]. The results of these tests provide insight into the ability of individuals to ambulate in a community. Timed walking tests are used under multiple conditions and cover a wide age group. For children, there are several timed walking tests available; Modified Timed Up and Go Test (MTUG) [6], 6-minute Walk Test (6MWT) [7], 1-minute Walk Test (1MWT) [8], 30-Second Walk Test [9], Standardized Walking Obstacle Course [10], and Timed Up and Down Stairs Test [11]. The most commonly used for children are the 10MWT and MTUG [12]. All the above-mentioned tests are implemented on a level floor except the Standardized Walking Obstacle Course and Timed Up and Down Stairs Test. The Standardized Walking Obstacle Course involves walking through a long curved standardized obstacle course while stabilizing a tray with both hands. With the test requirements, it can be used only in children able to walk independently with no assistive device [10].

The Obstacles Test and Curb Test are timed walking tests that emerged from the Spinal Cord Injury Functional Ambulation Profile (SCI-FAP) to evaluate performance on common functional walking tasks [13]. The SCI-FAP is a valid, reliable, and responsive measure of walking skills for adults with SCI [13,14]. It has been used in research to validate multiple assessment tools [15,16] and to measure walking capacity during or after interventions [17–21]. The original SCI-FAP consists of seven tasks and it has been reduced to four tasks in the Modified SCI-FAP [13,14]. The original seven tasks are (1) walking on a carpet, (2) the up-and-go task, (3) walking above and around obstacles, (4) walking up and down stairs, (5) walking a specific distance while carrying a bag, (6) a curb/step task, and (7) and navigating through a door [13]. A specific calculation of scores on individual tasks makes up the total SCI-FAP score. Two SCI-FAP tasks – walking over and around obstacles and the curb/step task – were taken to establish the Obstacles Test and Curb Test, and they were modified for children with or without assistive devices [22].

For the children's Obstacle Test, the pathway is straight instead of turning around a trash can and returning to the start line, time is measured between two lines added within the pathway (1 m after the start line and 1 m before the end line) to allow acceleration and deceleration, the obstacles are adjusted according to the leg length of each child, and, finally, the length of obstacles for children using assistive devices is 0.25 m (instead of 0.5 m). For the Curbs Test, the only modification is adding 2 m to the pathway to allow for acceleration and deceleration, like with the Obstacles Test. Children are allowed to get on and off the platform by stepping or crawling [21].

Establishing normative values is crucial for the accurate interpretation of test results in scientific use and clinical practice [23]. Having reference values for the Obstacles Test and Curb Test would provide additional value for researchers who aim to study functional mobility, gait speed, or dynamic balance in children. Currently; however, the normative values for the Obstacles Test and Curb Test in children do not exist. This is a prerequisite for designing and carrying out future studies in children with and without disabilities. Therefore, the aims of this study were to establish normative values for the Obstacles Test and Curb Test by assessing the influence of sex, age, height, weight, and BMI% on the obtained values and developing prediction equations.

Methods

Design

This cross-sectional study was conducted from December 2020 to February 2021 in five recreational centers for children located in different geographical areas of Riyadh City, Saudi Arabia.

Participants

A convenience sample of 240 typically developing children of both sexes was recruited for this study. They were aged 6–11 years old and had been born at full term. Children who were uncooperative or had a hearing or severe visual impairment, neurological disorders, orthopedic conditions, trauma, or pain that affected their walking or balance were excluded [22]. The children were divided into six age groups in 1-year increments. Each group had 40 children with an equal number of boys and girls.

A 'rule of thumb' calculation was used to estimate the required sample size of the typically developing children: $N > 104 + m$, where N is the sample size, and m is the number of independent variables. In our case, there were five (sex, age, height, weight, and BMI%). Therefore, the estimated required sample size was 109 (104 + 5) [24]. For both sexes, we doubled the estimated sample size and added approximately 10% in expectation of incomplete tests. That provided us with a final target sample of 240 children.

An ethical approval (Institutional Review Board) was obtained from the College of Medicine, King Saud University (KSU) (Reference ID: 20/0802/IRB), and permissions from the children's recreational centers were obtained. The parents of all the participants signed informed consent, and an appropriate assent was provided by the children according to their age before conducting the study.

Demographic characteristics

Data on sex and age were gathered. A calibrated scale was used to determine the height (cm) and weight (kg) of the participants. They were instructed to take off their shoes and stand upright during the measurements. The BMI% values were calculated and categorized as underweight, healthy weight, overweight, and obese using reference growth charts from the Centers for Disease Control and Prevention [25].

Procedure

Obstacles Test

The Obstacles Test is a walking assessment that involves stepping over two Styrofoam obstacles and walking around a trash can [13,22]. The pathway is approximately 8.5 m in length. The green tape was used to indicate the start and end lines at 6 m before the basket and 2 m after the trash can (see Fig. 1a). Additionally, the path was marked with blue tape 1 m after the start line and 1 m before the end line. The time was measured when the child was walking between the blue lines to allow for acceleration and deceleration. Obstacles were set at 2.5 m and 4 m from the start line. The two obstacles were constructed so that their widths were 10–15% and their heights were 20–25% of the child's leg length. The trash can was around 56 cm in width and 69.5 cm in length. The child should first stand behind the start line. The child then walks in a straight line, steps over the obstacles, walks around one side of the trash can, and passes the end line [22].

When the child is standing behind the start line, they were instructed as follows: 'When I say go, walk at a fast speed—without running—step over the Styrofoam obstacles, go around the trash can on either the right or left side, and then walk until you reach the green line. Don't touch the obstacles or trash can. If you do or they fall, do not stop, continue walking until you reach the green line'. The test was demonstrated once, and the child was given one practice trial. After that, the child had one attempt to complete the test and the time was recorded. A 10% time penalty was added to the recorded time if the child touched one or more obstacles with their body [22].

Curb Test

The Curb Test is a walking test that involves stepping on and off a wooden platform that is meant to mimic a curb [13,22]. The pathway was approximately 5.5 m in length. The start and end lines were marked by green tape at 2 m before and 2 m after the wooden platform (see Fig. 1b). The path was marked at 1 m after the start line and 1 m before the end line with blue tape. The time was measured when the child walked between the blue lines, allowing for acceleration and deceleration. The wooden platform was approximately 21 cm in height, 122 cm in length, and 81 cm in width. The child is asked to stand behind the start line, walk in a straight line toward the wooden platform, step onto it, walk across, step down to the ground, and then cross the end line [22].

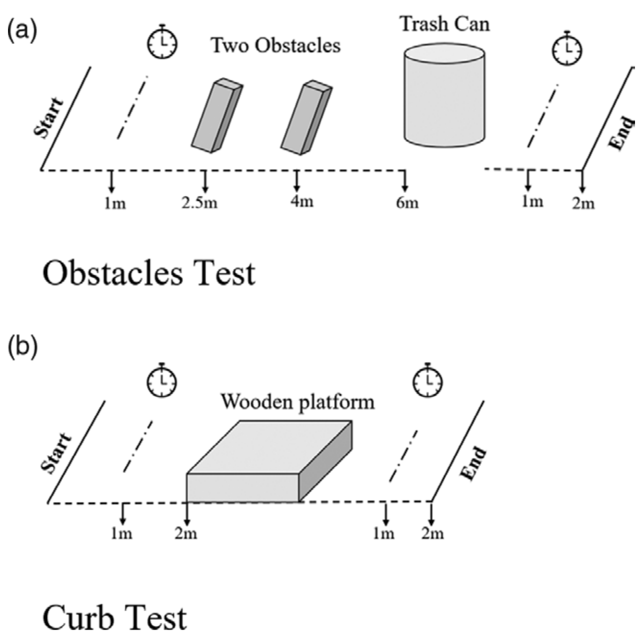
While standing behind the start line, the child was instructed as follows: 'When I say go, walk at a fast speed, step on the curb, walk across, then step off, and walk until you reach the green line'. The test was demonstrated once and one practice trial was given. After that, the child had one attempt to complete the test. The Curb Test guidelines suggest offering the child a choice of stepping or crawling as a mode for getting on and off the platform [22].

Statistical analysis

IBM SPSS Statistics software version 28.0 was used for the data analysis. The normality of the data was verified through the Shapiro-Wilk test. Data were presented as means ± SD or quartiles [first, second (median), and third] according to their distribution. Categorical data were expressed as frequencies and percentages. Independent sample *t*-tests (if the data were normally distributed) and Mann–Whitney *U*-tests (for non-normal data) were used to compare the data between the sexes.

For each test, a two-way analysis of variance (ANOVA) was performed to assess the main effect of sex and age and the sex × age interaction. Tukey's honestly significant difference (HSD) post hoc analysis was used to compare differences in each pair-wise condition. According to Cohen's guidelines [26], eta-squared (η^2) values of 0.01, 0.06, and 0.14 represented small, medium, and large effect sizes, respectively. Correlations among the study variables were assessed using Pearson's or Spearman's correlation coefficients. The eta (η) test was used to examine the correlation of the Obstacles Test and Curb Test scores with sex [27]. Guidelines developed by Chan [28] were used to interpret the correlations (no correlation <0.1, poor 0.1–0.2, fair 0.3–0.5, moderate 0.6–0.7, very strong 0.8–0.9, perfect correlation 1). A stepwise regression was used to identify predictors of the Obstacles Test and Curb Test results and their order of importance. Collinearity between the variables was identified by a variance inflation factor (VIF) at a cutoff point of 10 or higher [29]. The level of significance was set at $P \leq 0.05$.

Fig. 1



(a) Obstacles Test; (b) Curb Test [22].

Results

The characteristics of the children and the average time taken by each age group to complete the Obstacle Test and Curb Test are shown in Table 1. According to the Shapiro-Wilk test, all data were normally distributed ($P > 0.05$) except for BMI% ($P < 0.001$). Overall, there were no significant differences between the sexes except for a few exceptions. The 9-year-old boys were significantly taller and heavier than the girls of the same age. The 10-year-old boys weighed significantly more than girls of the same age. Finally, the 11-year-old boys were significantly taller and completed both tests significantly faster than the girls. Regarding BMI%, the distribution of the children by category was as follows: underweight (10.4%), healthy weight (51.6%), overweight (20.8%), and obese (17%).

A two-way ANOVA revealed no statistically significant interaction between age and sex for either the Obstacles Test [F (5, 228) = 1.97, P = 0.08] or Curb Test [F (5, 228) = 0.95, P = 0.45]. For both tests; however, there was a significant main effect of age [F (5, 228)] = 7.31, P < 0.01, and [F (5, 228) = 8.25, P < 0.01, respectively] and sex [F (1, 228) = 6.65, P = 0.01 and F (1, 228) = 4.26, P = 0.04, respectively]. Age had a higher influence on the Obstacles Test score than sex (η^2 = 0.14 vs. η^2 = 0.03). Similarly, age had a higher influence than sex on the Curb Test score (η^2 = 0.15 vs. η^2 = 0.02). Boys were significantly faster than

Table 1 Anthropometric characteristics and normative data of the Obstacles Test and Curb Test

	Girls (N=20 children in each age group)					Boys (N=20 children in each age group)				
Age (years)	Height (cm)	Weight (kg)	BMI% (%)	Obstacles Test (sec)	Curb Test (s)	Height (cm)	Weight (kg)	BMI% (%)	Obstacles Test (s)	Curb Test (s)
6	112.70±6.11	20.84±5.23	74.00 (12.37, 93.40)	5.72±0.58	3.03±0.38	111.25±7.68	19.60±3.43	45.65 (15.57, 94.65)	5.88±1.01	3.06±0.40
7	122.45±6.56	23.64±4.83	52.65 (21.82, 81.60)	5.38±0.78	2.98±0.43	120.25±8.31	23.32±5.51	61.00 (11.45, 88.47)	5.51±0.65	3.00±0.46
8	125.95±6.48	26.83±5.80	63.05 (13.25, 93.62)	5.51±0.77	2.92±0.37	128.40±5.82	28.77±3.40	84.05 (47.15, 93.95)	5.12±0.74	2.86±0.50
9	130.60±5.77	30.52±6.54	73.40 (23.22, 88.90)	5.29±0.79	2.82±0.32	135.45±5.68*	36.39±7.12*	91.50 (62.17, 96.65)*	4.96±0.68	2.68±0.37
10	139.25±9.10	33.86±8.05	57.45 (27.22, 77.32)	5.22±0.58	2.75±0.43	142.80±6.64	41.09±8.52**	77.55 (48.90, 97.30)*	4.85±0.83	2.50±0.49
11	145.65±8.43	41.60±12.5	71.05 (9.80, 92.65)	5.27±0.68	2.73±0.38	151.80±3.07**	43.86±6.25	81.95 (62.63, 91.30)	4.59±0.73*	2.46±0.39*
Total	129.43±12.94	29.55±10.17	62.70 (22.57, 88.50)	5.39±0.71	2.87±0.39	131.66±14.99	32.10±10.74	78.95 (42.27, 94.37)*	5.15±0.88*	2.81±0.45*

Data are represented as mean ± SD unless otherwise noted. BMI% data represented as median (first, third quartiles).
BMI%: BMI percentile, N: Number of participants.
*Significant difference between boys and girls $^*P<0.05$, $^{**}P<0.01$.

girls on both the Obstacles Test (5.15 s vs. 5.39 s with a SE of 0.68 s; $P<0.05$) and Curb Test (2.81 s vs. 2.87 s with a SE of 0.04 s; $P<0.05$).

For both tests, the mean time decreased with an increase in age, as shown in Figs 2 and 3. The results of Tukey's HDS post hoc analysis revealed that, for the Obstacles Test, children aged 6 years were significantly slower than the rest of the children ($P<0.05$). There was also a significant difference between children aged 7 years and those aged 10 years and above ($P<0.05$). In addition, children aged 8 years were significantly slower than those aged 11 years ($P<0.05$). Regarding the Curb Test, there were significant differences between the youngest children (aged from 6 to 9 years) and the older ones.

There was a fair negative correlation between the Obstacles Test with height ($r=-0.41$, $P<0.01$), age ($r=-0.35$, $P<0.01$), and weight ($r=-0.32$, $P<0.05$). Furthermore, the Curb Test also had a fair negative correlation with height ($r=-0.42$, $P<0.001$), age ($r=-0.39$, $P<0.01$), and weight ($r=-0.31$, $P<0.01$). The η test showed a poor correlation between both Obstacles Test and Curb Test with sex ($\eta=0.15$ and 0.12, respectively). Performance on both tests did not significantly correlate with BMI%.

Sex, age, height, and weight were associated with performance on the Obstacles Test and Curb Test. Once the collinearity and VIF values were examined, age, sex, and weight were used in a stepwise regression analysis to derive the predictors and develop the regression equations. Age and sex were the most notable and significant predictors for both test scores. They accounted for 14% and 17% of the total variance in the Obstacles Test and Curb Test times, respectively (see R^2 in Table 2).

The prediction equations were as follows:

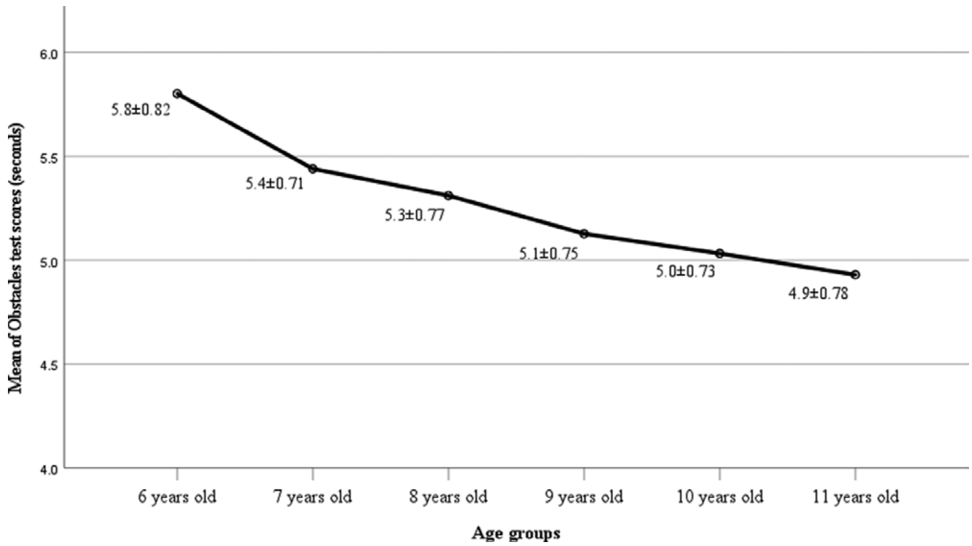
$$\text{Obstacles Test (s)} = 6.59 - [0.16 \times \text{Age (year)}] + [0.25 \times \text{Sex (boys} = 0 \text{ and girls} = 1)]$$

$$\text{Curb Test (s)} = 3.66 - [0.10 \times \text{Age (year)}] + [0.11 \times \text{Sex (boys} = 0 \text{ and girls} = 1)]$$

Discussion

This study aimed to establish normative values for the Obstacles Test and Curb Test; assess the association of sex, age, height, weight, and BMI% with their completion times; and develop the prediction equations. On average, boys were faster than girls, and older children performed better than younger ones. Age and sex were the most important predictors for both tests based on the regression analysis.

Fig. 2

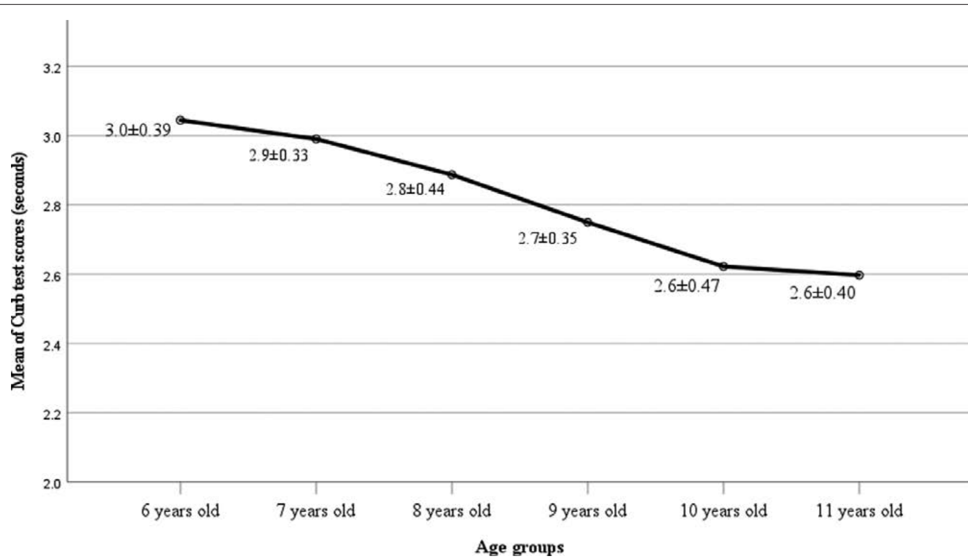


Obstacles Test scores (mean ± SD) by age. Time to complete the test decreases as children's ages increase.

In Kane *et al*'.s study [21], both tests were performed at a fast speed and self-selected speed [22]. They found that the Obstacles Test performed at a fast speed was valid unlike the performances at a self-selected speed. Moreover, the reliabilities of both tests were higher at a fast speed. Therefore, in this study, the Obstacles Test and Curb Test were performed with instructions to proceed at a fast speed. Implementing walking at fast speeds, as used in this study, is consistent with established timed walking tests (10 MWT, MTUG, and Timed Up and Down Stairs), which are more appropriate when performed at a fast speed [11,30–35].

All the children completed the tests with no difficulties. Age had a significant influence on both the Obstacles Test and Curb Test results. On the basis of the literature, age is known to influence the results of other timed walking tests as well [36,37]. Children take less time to complete the tests as they become older because motor tasks improve with age [32,36–38]. This

Fig. 3



The Curb test score (mean ± SD) by age. Time to complete the test decreases as children's ages increase.

Table 2 Stepwise Regression Analysis for the Obstacle Test and Curb Test

	Model	R	R2	Unstandardized Coefficient		Standardized Coefficient	Sig.
				B	Std. Error	Beta	
Obstacles Test							
1	(Constant)	0.35	0.12	6.71	0.26	−0.35	<0.01
	Age			−0.16	0.03		<0.01
2	(Constant)	0.38	0.14	6.59	0.26		<0.01
	Age			−0.16	0.03	−0.35	<0.01
	Sex			0.25	0.1	0.16	0.01
Curb Test							
1	(Constant)	0.39	0.15	3.72	0.14	−0.40	<0.01
	Age			−0.10	0.02		<0.01
2	(Constant)	0.41	0.17	3.66	0.14		<0.01
	Age			−0.10	0.02	−0.40	<0.01
	Sex			0.11	0.05	0.13	0.04

R and R2: Measures of strength between model and dependent variables.
Sig, Significance level ($P<0.05$), B: Unstandardized coefficient.

may be explained by the maturation of body size and strength, as well as the improvement of balance with age [39].

In the current study, sex had a statistically significant effect on the Obstacles Test and Curb Test results in that boys were faster on average. This could be related to an increase in height for boys at a certain age as a result of puberty, which leads to an increase in stride length [38,40]. These findings are in line with previous research on other walking tests, such as TUG [37]. The reasons for this may be differences in physical development, changes in lean body weight and body fat, and changes in hormones [41]. Itzkowitz *et al.* [37] found a significant influence of sex in that boys were faster than girls; however, the differences did not exceed the 2-s clinically important difference based on Nicolini-Panisson and Donadi's study [32]. Other studies found no significant influence of sex on walking tests, such as TUG and 10 MWT [35,42,43].

The two tests indicated a fair negative correlation with age, height, and weight, a poor correlation with sex, but none with BMI%. As they are related to growth, height and weight generally increase together, and this could explain the similar correlations of age, height, and weight with the results of the Obstacles Test and Curb Test. Regarding sex, as we described above, boys on average were faster than girls in most of the age groups, and this would explain the main effect of sex on both test results. Additionally, more than half of the children (51.6%) were identified as having healthy weights, which may have affected the correlation of the scores of both tests with BMI%.

These findings were consistent with those of other timed walking tests [6,32,35,37]. Both of our prediction equations took into account factors similar to the MTUG test equation, which considered age alone or age and weight as the main predictors [32,36,37]. In this study, age and sex were found to be the main predictors of both the Obstacles Test and Curb Test results. However, despite poor correlations between sex and both tests, the main effect of sex cannot be ignored. According to the regression models, age with sex explained more variance in the Obstacles Test and Curb Test results than age alone. The coefficient of determination (R^2) values for both regression models were acceptable (between 0.12 and 0.17) [27].

Although this study is the first to estimate normative values for the Obstacles Test and Curb Test, it has some limitations. Children were exclusively recruited from one city and limited to 6–11 years old. Thus, the predictive equations should be validated elsewhere. Comparisons between the Obstacles Test and Curb Test with other timed walking tests (e.g. TUG and 10 MWT) are needed. In line with Kane *et al*'.s study, future research may also look into the psychometric properties (validity, reliability, and sensitivity) of the two tests with a larger sample of children with disabilities (e.g. cerebral palsy and spina bifida) [22]. Other factors that affect walking speed, such as leg length, joint mobility, muscular strength, and energy levels, should be investigated further over broader geographical areas [44].

In conclusion, this study established the normative values for the Obstacles Test and Curb Test and provided the respective prediction equations for typically developing children aged 6–11 years. The predicted values may be helpful to determine whether the performance of a child falls within or outside the age-matched norms. In addition, the provided norms and prediction equations may be used in clinical research for the evaluation of interventions targeting disabled children.

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Conflicts of interest

There are no conflicts of interest.

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