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Reliability of the TUDS test for children with cerebral palsy

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Abstract

Background: The timed up and down stairs (TUDS) test is widely used to assess the time required by a patient to climb up and down stairs as a measure of functional mobility.

Aim: This cross-sectional study was conducted to examine test-retest, intra-rater, and inter-rater reliability of TUDS test in children with cerebral palsy (CP).

Subjects: Forty children (22 boys and 18 girls) with unilateral and bilateral spastic CP were selected from the Cairo University Hospitals to participate in this study. The age range was 3–9 years. Subjects classified according to Gross Motor Function Classification System-Expanded and Revised (GMFCS-E&R) in categories 1 or 2 only were included. All subjects with muscle tone above normal (spasticity) were included.

Methods: The TUDS test was performed at two testing sessions on the same day to determine test-retest reliability; the main investigator scored all children at real time using a stopwatch and then rescored them later from video recording to determine intra-rater reliability. Another research team member scored all children from video recording to determine inter-rater reliability. Scoring was carried out at real time and from video recordings of the trials. Reliability was estimated using intra-class correlation coefficients (ICC).

Results: The TUDS test showed excellent reliability for all measured types of reliability. ICC score for test-retest reliability was 0.978, ICC score for intra-rater reliability was 0.999, while ICC score for inter-rater reliability was 0.998 and 0.999.

Conclusion: The TUDS test is a reliable outcome measure for children with spastic CP. It can be measured at real time or later from video recording of the performance trials. The TUDS test is an important tool in the re-evaluation process of children with CP.

Keywords: Cerebral palsy, Children, GMFCS-E&R, Reliability, Stair climbing, TUDS test

Background

Cerebral palsy (CP) is a term used to describe a set of permanent mobility and postural problems that result in limitations in activity and participation; it is caused by nonprogressive disruptions in the developing fetus or infant brain [1].

The most common cause of functional impairment in children is CP. In school-aged children, it accounts for 60% of severe motor impairments [2]. During infancy or the preschool years, signs and symptoms of CP arise. Exaggerated reflexes, floppiness or spasticity of the limbs and trunk, odd posture, involuntary movements, unstable walking, or some combination of these are all signs of CP [3].

Spasticity and musculoskeletal impairments limit functional mobility in children with CP. Despite the fact that over 60% of children with CP can walk, they have limitations in balance and functional mobility [4, 5].

To assess functional outcomes of intervention, reliable and valid measurements of functional activities that represent features of underlying postural control are

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necessary. The timed up and down stairs (TUDS) test was created as a functional mobility outcome measure that might represent changes in the musculoskeletal and neuromuscular systems involved in postural control [6].

The TUDS test is identified as a reliable and valid test for ambulant children with and without CP at the age of 8 to 14 years. Reliability of TUDS test for younger children needs to be properly calculated so that the test can be used with those children [6, 7].

The purpose of the current study is to investigate the reliability of TUDS test with children with CP in early childhood (3–9 years). The study directly adds value to clinical practice providing useful, convenient, easy-to-administer, time-saving, valid and reliable outcome measure to be used in the assessment of functional mobility of children with CP.

Methods

Children with CP were recruited in this cross-sectional study using convenience sampling method from pediatric outpatient clinics of the Faculty of Physical Therapy in Cairo University and Abo El-Reesh Children's Cairo University Hospital, Egypt.

Forty participants (22 boys and 18 girls) were selected as illustrated in Fig. 1 according to the following criteria:

1) Age range included children 3–9 years old.
2) All subjects were diagnosed with spastic CP either unilateral or bilateral type.
3) Subjects classified according to Gross Motor Function Classification System-Expanded and Revised (GMFCS-E&R) in categories 1 or 2 only were included.
4) All subjects with muscle tone above normal (spasticity) were included.

Children were excluded if they have the following:

1) History of comorbidities as genetic or neurologic disorders associated with CP
2) Orthopedic surgeries in the past 6 months
3) Botulinum toxin injection in the lower limbs within the past 3 months
4) Difficulty in following instructions

This sample size was established from the highest sample size data found in previous research on the TUDS test ($N = 12–49$) [8–10].

Procedures

The study was approved by the ethical committee of Faculty of Physical Therapy, Cairo University (REG.N. 012/003402). Before beginning the testing procedures, parents of all participants were interviewed and provided a written consent to agree about the participation of their children in the study. Any exclusion criteria that might exist were examined. Demographic data as age and gender were documented for all children before starting the evaluation procedures. Also, anthropometric data as height, weight, and body mass index (BMI) were measured before starting the evaluation procedures. The investigator made sure that children are not tired or hungry during testing to maintain alertness and concentration.

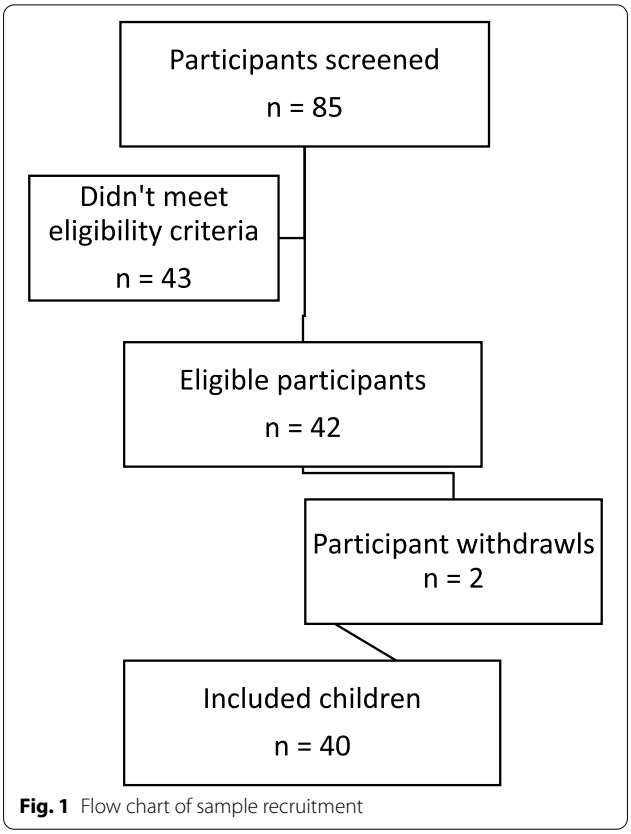

Fig. 1 Flow chart of sample recruitment

Gross motor function classification system—expanded and revised

The GMFCS-E&R is valid and reliable when applied by medical personnel or caregivers [11]. According to Palisano et al. [12], the researcher asked the child to do functional tasks from each level of the user's manual to determine which level the child fits in according to age band. Subjects classified in categories 1 or 2 only were included.

Timed up and down stairs test

The researcher then begins to illustrate and demonstrate TUDS test procedures before any trials are conducted.

Participants were advised to face forward when ascending and descending the stairs. The child was not required to return to the starting mark. Handrails were available on one side only. The participants were allowed to wear shoes, but no orthotics were allowed. Limited number of demonstrations and trials was permitted to all participants.

According to Corral et al. [13], participants were asked to stand 30 cm from the bottom of one set of stairs (10 steps, each 16 cm in height and 31.5 cm in depth). The subjects started the trial on the count of 3 to go up the stairs as quickly as possible while maintaining caution, turn around on the highest step, and descend again until both feet are on the bottom step. The researcher walked along beside the participant to ensure safety and to provide verbal encouragement as needed.

The child was not allowed to run, jump, or skip steps; otherwise, any pattern of climbing was acceptable (such as step to or step over strategy, facing forward or sideway, not holding rails, or holding with 1 or both hands).

The time required to ascend and descend stairs was measured in seconds from the count of 3 until both feet returned to the bottom step. Shorter times indicate better functional ability.

All children were filmed during performance of the test. To determine test-retest reliability, each participant performed the test on 2 sessions, and the rest interval between both testing sessions was 20 min. Participants were instructed to complete two trials of the test in each session, with an optional 1-min break in between. The better of the two trials was employed in the analysis.

The main investigator scored all children at real time using a stopwatch and then rescored them later from the video to determine intra-rater reliability. Another research team member scored all children from the video to determine inter-rater reliability. Each investigator did not have any knowledge of the scores of other trials during scoring.

Statistical analysis

Descriptive statistics of mean ± standard deviation (SD) and frequency was carried out to calculate the measured variables. Test-retest, intra-rater, and inter-rater reliability were expressed as intra-class correlation coefficients, ICC (2, 1). Repeated measurements by the same rater on real-time measurement (T1-T2) of TUDS test were used to calculate test-retest reliability. Repeated measurements by the same rater on real-time and video recording measurement were used to calculate intra-rater reliability. Measurements by different raters on video recording measurements were used to calculate inter-rater reliability. The level of significance for all statistical tests was set at $p < 0.05$. Statistical analysis was conducted through the Statistical Package for Social Studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

Table 1 Basic characteristics of all participants

	Mean ± SD	Maximum	Minimum	Range
Age (years)	6.18 ± 1.65	8.83	3.08	5.75
Weight (kg)	23.47 ± 7.84	39.4	11	28.4
Height (cm)	113.47 ± 11.77	135	88	47
BMI (kg/m^2)	17.72 ± 3.23	25.7	11.94	13.77
Gender				
Girls	18 (45%)			
Boys	22 (55%)			
Diagnosis				
Unilateral	22 (55%)			
Bilateral	18 (45%)			
GMFCS				
Level I	32 (80%)			
Level II	8 (20%)			

SD standard deviation

Table 2 Descriptive statistics of TUDS test measurements of the study group

TUDS (s)	Mean ± SD	Maximum	Minimum
T1 real time	41.50 ± 45.51	219.90	12.77
T2 real time	37.95 ± 43	221.33	12.33

SD standard deviation

Results

Participants

Forty children with cerebral palsy participated in this study. Table 1 shows the subject's characteristics of the study group.

TUDS test measurements of the study group

The mean ± SD value of TUDS test of the study group at T1 was 41.50 ± 45.51 s with maximum value of 219.90 s and minimum value of 12.77 s. The mean ± SD value of TUDS of the study group at T2 was 37.95 ± 43 s with maximum value of 221.33 s and minimum value of 12.33 s (Table 2).

Reliability of TUDS test

TUDS test showed excellent reliability for all measured types of reliability. ICC for test-retest reliability (T1 real time — T2 real time) was 0.978, with 95% *CI* 0.954–0.989. ICC for intra-rater reliability (T1 real time — T1 video recording) was 0.999, with 95% *CI* 0.998–0.999, while (T2 real time — T2 video recording) was 0.999, with 95% *CI* 0.9995–1. ICC for inter-rater reliability (T1 1st rater video recording — T1 2nd rater video recording)

was 0.998, with 95% *CI* 0.997–0.999, while (T2 1st rater video recording — T2 2nd rater video recording) was 0.999, with 95% *CI* 0.984–1, as illustrated in Table 3.

Discussion

Test-retest reliability was measured once between the score of the 1st trial (T1) and the score of the 2nd trial (T2) by the 1st rater at real time, while intra-rater and inter-rater reliability each one of them was measured twice as the relationship between different scores of the 1st trial and again as the relationship between different scores of the 2nd trial.

The high level of reliability demonstrated in this study is a result of the small differences between different scores of raters, as the differences did not exceed 1 s in most of the scores. These differences presented as fractions of a second in most cases are attributed to rater's individual characteristics as reaction time between hearing the starting cue and pressing the recording button of the stopwatch and also between seeing both feet of the participant reaching the floor and pressing the stopping button of the stopwatch.

The results of this study show excellent reliability for children aged 3 to 9 years with CP, which come in accordance with the results of previous studies that demonstrated high reliability of TUDS test for children aged 8 to 14 years [6, 7, 13]. By adding the results of this study to the previous literature, it is suggested that TUDS test has strong evidence of reliability for children with CP at different ages starting from age 3 years until age 14 years.

Excellent intra-rater reliability of TUDS test indicates that scoring of the test can be done later from video recording of the performance of the child without the need for scoring at the time of the trial with a stopwatch which agrees with previous literature [6]; this can help the evaluator focus his attention on providing continuous instructions and encouragement for the child and protecting the child from falling. Giving instructions, taking safety measures, and scoring the time of the trial were one of the challenges that appeared while conducting this study.

Another challenge was finding a staircase that fits the criteria of the test in previous literature. Using the criteria of the test previously used by Corral et al. [13] which states the number of steps as 10 steps was easier to find than the criteria in other studies which stated higher number of steps [6, 8, 9]. Also, it is more applicable to modify the staircase if it contains more than 10 steps by excluding the extra steps and starting after them, but it would be harder to add more steps if we have a smaller number of steps than the required number.

Advantages and uses of TUDS test are as follows:

1) The test is free, so the only cost is the time required to administer the test which does not exceed 5 min to apply if the evaluator has a staircase that is suitable to apply the test.
2) The tools needed are a camera and a sticker to mark the starting line.
3) It can be used as a screening test to identify children with limitations in functional mobility.
4) Another use as an evaluative measure to determine the ability of the child to successfully and independently transfer between different settings in his environment
5) In addition to using it as an observational measure to notice the differences in the pattern of climbing stairs and level of support needed from handrails
6) And finally, as a re-evaluation measure to document improvements in the performance of the child throughout the course of rehabilitation [7, 8, 10, 14]

This study of the TUDS test has a significant point of strength that it is the first study to be applied on Egyptian children or even children from the Middle East. One of the limitations of this study was including patients with spastic type of CP only, so further research is needed for patients with other types of CP as dyskinetic, ataxic, and hypotonic CP [12], as well as testing TUDS test for

Table 3 Test-retest, intra-rater, and inter-rater reliability of the TUDS test

		ICC	(95% CI)	
			Lower bound	Upper bound
Test-retest reliability	**T1 real time — T2 real time**	0.978	0.954	0.989
Intra-rater reliability	**T1 real time — T1 video recording**	0.999	0.998	0.999
	T2 real time — T2 video recording	0.999	0.995	1
Inter-rater reliability	**T1 1st rater — T1 2nd rater**	0.998	0.997	0.999
	T2 1st rater — T2 2nd rater	0.999	0.984	1

ICC intra-class correlation coefficient value, *CI* confidence interval

different types of validity on the same age group (early childhood).

Conclusion

The TUDS test is a reliable outcome measure for children aged 3–9 years with spastic CP. It can be measured at real time or later from video recording of the performance trials. The TUDS test is a clinically useful, safe, low-cost, and easy-to-administer assessment tool.

It can be used for documentation of improvements in higher functional abilities as climbing up stairs, turning around, and climbing down stairs. The performance on TUDS test is closely related to components and prerequisites of walking as gait speed, single-limb stability, push-off mechanism, and limb clearance. This test can be a main functional measure in the re-evaluation process of high-functioning children with CP at levels 1 and 2 of the GMFCS-E&R.

Abbreviations

TUDS: Timed up and down stairs; CP: Cerebral palsy; ICC: Intra-class correlation coefficients; GMFCS-E&R: Gross Motor Function Classification System-Expanded and Revised; BMI: Body mass index; T1: First measurement; T2: Second measurement; SD: Standard deviation; CI: Confidence interval; SPSS: Statistical Package for Social Studies; IBM: International Business Machines Corporation.

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Authors' contributions

AA is the main author, SH participated in scoring of the test and writing of the research, and FA was the main supervisor and reviewer. The authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study was approved by the ethical committee of Faculty of Physical Therapy, Cairo University (REG.N. 012/003402). All cases presented a written informed consent which was approved by the ethics committee.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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