Original Article

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Physiotherapy Section

Association of Timed Up and Down Stairs Test with Anthropometric and Physiological Parameters in Children Aged 6-14 Years: A Cross-sectional Study

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ABSTRACT

Introduction: Timed Up and Down Stairs (TUDS) test is a functional movement performance assessment which evaluates the time consumed in order to ascend and descend a set of stairs. However, the normative reference value for the TUDS test remains limited in the Indian paediatric population. Additionally, the relationship between anthropometric and physiological parameters and TUDS performance has not been adequately explored in developing countries.

Aim: To establish the reference score for TUDS performance in school-aged children of six to 14 years, as well as examine the correlation between anthropometric and physiological factors with TUDS.

Materials and Methods: This cross-sectional study was conducted at a sports complex located within the Maharishi Markandeshwar (Deemed to be University), Mullana-Ambala, Haryana, India from March 2025 to January 2026. A total of 500 healthy school-going children were recruited through purposive sampling. Anthropometric (age, gender, height, weight, body mass index, and bilateral limb length) and physiological measurements {Heart Rate (HR), blood pressure and Oxygen Saturation (SpO_2)} were recorded, followed by TUDS testing. Statistical analysis was performed using Spearman correlation and multiple linear regression, with p-value <0.05 considered statistically significant.

Results: The sample included 224 girls (44.8%) and 276 boys (55.2%) with a median age of nine years. Multiple regression analysis demonstrated a significant relation with age, gender and body weight of TUDS test performance, showing (25.7%) of the variance (R^2=0.257, F (14,485)=11.9, p-value <0.001). Age of the children demonstrated the strongest association, whereas height, lower limb length and physiological parameters showed minimal independent influence.

Conclusion: TUDS test performance was primarily determined by anthropometric factors with negligible impact from physiological variables in school-aged children. Age and body size were the primary determinants of TUDS performance, highlighting the importance of maturational factors when interpreting paediatric functional mobility tests.

Keywords: Anthropometric measurements, Body weight, Child, Heart rate, Oxygen saturation, Stair climbing

INTRODUCTION

Functional movement performance is an essential component of basic functioning in everyday activity, which requires active participation without any assistance. Examples are standing, walking, running, jumping, and climbing up and down stairs. These movements allow functional engagement of participants to enhance their functional health status [1]. The TUDS test is a reliable functional movement performance assessment tool which demonstrates excellent reliability to assess the function of the neuromuscular system for the maintenance of postural stability [2]. The Association of Paediatric Chartered Physiotherapists elaborated on the usefulness of the TUDS test among children with and without cerebral palsy. Results showed that this test has good reliability and validity to assess gross motor function among children [3].

Anthropometric and physiological parameters play a significant role among children, which may influence their mobility while stair climbing. Previous literature has found a direct relationship between stair climbing and Systolic Blood Pressure (SBP), pulse rate and HR among adults. However, no association was found with Diastolic Blood Pressure (DBP) [4,5]. Moreover, stair climbing ability is strongly correlated with functional performance in children. Physiologically, children generally have higher HRs, smaller stroke volume, with incomplete metabolic and muscular maturation, including lower strength, power and aerobic capacity than adults. These developmental factors may result in variations in functional task performance [6].

The TUDS test enhances the postural control, established as one of the dynamic functional mobility outcome measures, raising the neuromuscular and musculoskeletal combined functions in daily life [7]. While performing the TUDS test, coordinated action of the gluteus maximus, vastus medialis, vastus lateralis, and vastus intermedius (quadriceps femoris group) along with the soleus [8]. To track the neuromuscular disease progression often missed by conventional muscle testing or gait analysis, TUDS test works as the key determinant [9,10]. Stair climbing generates large hip and knee joint moments, changes in limb length alter the joint mechanics, which can influence torque efficiency and overall stair performance [11,12].

In previous literature, TUDS test has served as a tool to evaluate functional capacity of participants with obesity, chronic pain and cancer [13-17]. Furthermore, functional mobility has predominantly been documented in small and Western-centric demographic samples examined the reliability, validity and functional application of the TUDS test in paediatric population [18,19]. There is a paucity of literature investigating the association between TUDS test performance with anthropometric and physiological characteristics such as age, height, weight, lower limb length, blood pressure, SpO_2 and HR, respectively. Even though TUDS is a comparatively brief test, it includes faster muscle contractions, postural control and coordination, which may elicit measurable cardiovascular changes [4-6]. The current study aimed to establish reference scores for TUDS performance in school-aged children of 6 to 14 years, as well as examine the correlation between anthropometric and physiological factors with TUDS test performance.

MATERIALS AND METHODS

This cross-sectional study was conducted at a school sports complex located within the university premises from March 2025 to January 2026. The National Ethical guidelines for biomedical and health research involving human participants {Indian Council of Medical Research (ICMR), 2017} and guidelines of the Helsinki Declaration (revised, 2013) were followed in the conduct of this study. Ethical approval was obtained from the Institutional Ethics Committee (IEC) of a recognised Institute, Maharishi Markandeshwar Institute of Medical Sciences and Research, Maharishi Markandeshwar (Deemed to be) University, a tertiary care hospital) situated in Mullana, Ambala, with IEC No. 3467. Permission to recruit participants was obtained from the respective school authorities, including the school principal and sports teachers. Before enrollment, the child's caregiver provided consent in writing after providing all study-related information, along with assent from the participants. Data collection was carried out at the school sports complex located within the university premises.

Inclusion criteria: Healthy school-going children aged 6 to 14 years, including both boys and girls, were recruited for this study. Children showing willingness to participation able to follow verbal instructions and capable of performing the TUDS test independently were included in the study.

Exclusion criteria: Participants with a history of musculoskeletal conditions affecting stair ambulation, cardio-respiratory or neurological disorders, and intellectual or learning disabilities that could interfere with test performance were excluded from the study.

Sample size: As the current study utilised a cross-sectional design, the sample size calculation was done considering the first objective which was to estimate reference values for TUDS test performance among healthy school going children using the proportion formula; $n=(Z^2pq)/d^2$ at 95% confidence level and 5% precision level. The proportion p=0.56 was arrived after considering the results of a pediatric research study which indicated variance in TUDS test performance [19]. Correlation and regression analysis followed thereafter to evaluate the relationship between TUDS and anthropometrical parameters as well as physiological factors. To increase precision for this new objective, the sample size was enlarged up to 500. Anthropometric and physiological assessments were conducted before the administration of the TUDS test. Demographic including anthropometric details like age, sex, height, weight, bilateral limb length and baseline physiological parameters such as HR, blood pressure and SpO_2 were recorded.

The TUDS test was administered following the procedure designed as per Zaino CA et al., [3]. Participants enrolled were instructed to be positioned 30 cm away from the base of the originating staircase and ascend the stairs at the fastest pace possible while maintaining safety. As soon as the participants reached the 10th staircase, they were instructed to pivot on the top stair and step downward until their bilateral feet made contact with the step at the base of the staircase. No running, skipping steps, or jumping was allowed on the stairs throughout test performance [3]. The interval needed to climb up and go down the stairs, consisting of 10 steps, each with a height of 16 cm and a width of 31.5 cm, was recorded in seconds using a stopwatch. The test commenced on verbal command "go" where the timer was also started, and it ended when the participant's contralateral foot returned to the bottom landing. Three attempts were executed with an inter-trial period of 5-minute recovery period between each attempt. Handrails were present on both sides of the staircase. Participants ascended and descended the stairs in a forward direction facing the staircase, without turning sideways or deviating laterally, while wearing comfortable footwear.

Vertical stature was assessed through a wall-mounted stadiometer of participants standing without footwear, heels against the wall, feet symmetrical and aligned, and arms relaxed by the sides. Body weight was recorded using a calibrated digital weighing scale (HO-18- Black). Lower limb length was measured bilaterally using a non elastic tape measure, spanning the distance between the Anterior Superior Iliac Spine (ASIS) and the medial malleolus. All the measurements were performed by a single trained assessor to minimise inter-rater variability. Leg dominance was not assessed in this study, as stair ambulation in the TUDS test is a bilateral task requiring coordinated use of both lower extremities, and performance is not typically influenced by leg dominance [20].

Physiological variables like SpO_2 and HR were noted using a pulse oximeter (Dr Trust), while blood pressure was measured pre- and post-test using a digital sphygmomanometer (Omron HEM-7124). The time window was 10 minutes to ensure recovery between repeated TUDS trials, and post-test of physiological measurements was recorded after completion of all trials of the TUDS test. Participants were provided with standardised instructions and a demonstration of the TUDS test before testing.

STATISTICAL ANALYSIS

The Statistical Package for the Social Sciences (SPSS) version 20.0 was used for statistical analysis. The descriptive statistics were represented in median with Interquartile Ranges (IQR) and 95% of Confidence Interval (CI) as the data was not following normal distribution, based on the Kolmogorov-Smirnov test. Spearman's rho correlation coefficient was used to examine the relationship between TUDS performance and anthropometric and physiological parameters. Multiple linear regression analysis was applied to determine independent predictors of TUDS performance, with a significance level set at p-value <0.05.

RESULTS

A total of 500 school-going participants participated in the study, including 224 (44.8%) girls and 276 (55.2%) boys. The median age of participants was nine years. Median height was 136 cm and weight 33 kg, with lower limb lengths around 76-77 cm bilaterally. Baseline cardiovascular parameters in these children were within normal paediatric ranges, with resting HR ~102 bpm, SBP ~106 mmHg, DBP ~69 mmHg, and SpO_2 ~97%. Following the TUDS test, only mild increases in HR and SBP were observed, while SpO_2 remained stable [Table/Fig-1].

Details	Median IQR	95% CI
Age (years)	9 (8, 11)	9.45-9.90
Height (centimetres)	136 (126, 147)	135.92-138.67
Weight (kilograms)	33 (26, 43)	34.48-36.98
Lower Limb Length right-side (centimeters)	76.35 (70, 84)	76.69-78.46
Lower Limb Length left-side (centimeters)	76.5 (70, 84)	76.66-78.43
Pre HR (beats/ minute)	102 (94, 112)	101.02-103.59
Pre SBP (mmHg)	106 (98, 114)	104.67-107.06
Pre DBP (mmHg)	69 (63, 75)	68.97-71.04
Pre SpO_2 (%)	97 (96, 98)	96.40-96.92
Post HR (beats/ minute)	106.50 (98, 116)	105.94-108.63
Post SBP (mmHg)	108 (98, 118)	106.69-109.36
Post DBP (mmHg)	70 (64, 76)	70.42-72.73
Post SpO_2 (%)	96 (95,97)	95.53-96.30

[Table/Fig-1]: Demographic details/anthropometric characteristics and physiological parameters.

Median completion times ranged from 6.33 to 6.42 seconds, with minimal inter-trial variability, reflecting consistent functional mobility and task performance among participants [Table/Fig-2].

Physiological variables demonstrated minimal association with TUDS time. Pre- and post-TUDS HR showed weak positive correlations with TUDS (r-value= 0.12 and r-value=0.11, respectively). SBP and DBP measured before and after the TUDS test exhibited negligible

Details	Median IQR	95% CI
TUDS 1 (second)	6.34 (5.80,6.98)	6.40-6.60
TUDS 2 (second)	6.33 (5.81,7.01)	6.39-6.59
TUDS 3 (second)	6.42 (5.88,7.06)	6.45-6.65

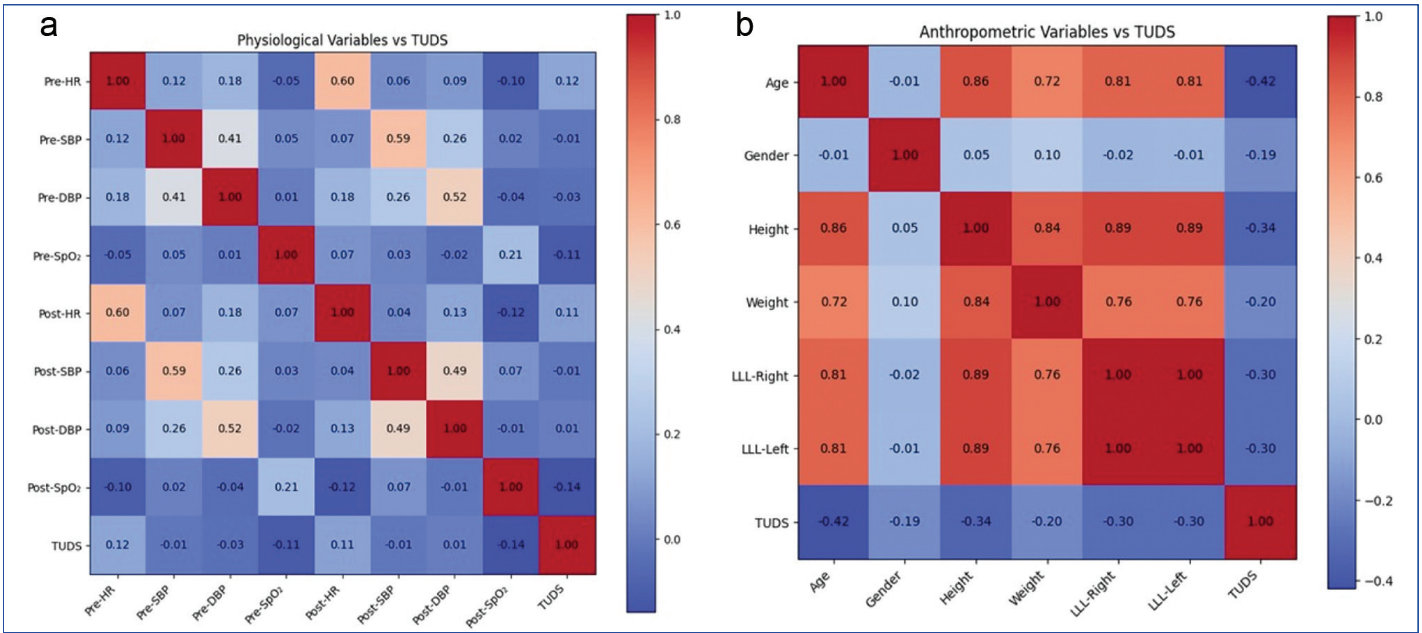
[Table/Fig-2]: Timed Up and Down Stairs (TUDS) performance across three assessments.

correlations with TUDS time (r values ranging from -0.03 to 0.01). SpO_2 showed weak negative correlations with TUDS time for both pre-test (r-value=-0.11) and post-test (r-value=–0.14) measurements [Table/Fig-3a].

Age showed a moderate negative correlation with TUDS time (r-value=-0.42). Height and lower limb length also demonstrated moderate negative correlations with TUDS (height: r-value=-0.34; right and left lower limb length: r-value=-0.30). Weight exhibited a weak negative correlation with TUDS time (r-value=-0.20). Gender showed no clinically meaningful relationship with TUDS time (r-value=-0.19) Bivariate correlation was weak, while multivariate regression identified a significant association. [Table/Fig-3b].

among school-going participants. The present investigation contributes to the existing literature by providing normative insights for TUDS performance in a relatively large cohort of Indian school-going children aged 6-14 years. Compared with previous study of Del Corral T et al., which included 258 participants, the current study employed a larger sample size (n=500) drawn from diverse geographic and cultural backgrounds within the Indian population. This broader representation strengthens the generalisability of the findings and provides valuable reference data for healthcare professionals and researchers working with paediatric populations in similar contexts [19].

The findings highlight the importance of growth-related anthropometric characteristics in influencing stair-climbing performance. In particular, age exhibited the strongest association with TUDS performance, indicating that increasing maturity and motor growth contribute to more efficient stair-climbing performance. Similarly, height and lower limb length were associated with improved stair-climbing efficiency. From a biomechanical perspective, taller individuals with longer lower limbs may benefit from longer stride lengths and improved leverage



[Table/Fig-3]: Spearman correlation matrix of TUDS performance with (a) Physiological variables and (b) Anthropometric variables.

To identify the combined influence of demographic, anthropometric, and physiological variables on mean TUDS performance, a multiple linear regression analysis was conducted. The overall regression model was statistically significant (F=11.9, p-value <0.001), indicating that the included predictors collectively explained variability in TUDS scores. The model accounted for 25.7% of the variance in mean TUDS time (R^2=0.257, adjusted R^2=0.236), reflecting a moderate explanatory capacity.

Among the predictors, age emerged as the strongest independent determinant of TUDS performance, demonstrating a significant negative association (B=-0.560, β=-0.569, p-value <0.001), indicating faster stair-climbing performance with increasing age.

Gender also showed a statistically significant association with TUDS scores (B=-0.840, β=-0.192, p-value <0.001), body weight demonstrated a positive association with TUDS mean score (B=0.050, β=0.287, p-value <0.001), In contrast, height, lower limb length, and physiological variables measured before and after the TUDS test including blood pressure, SpO_2, and HR did not demonstrate significant independent contributions to TUDS performance (p-value >0.05).

DISCUSSION

This study aimed to find the relationship between TUDS performance with anthropometric and physiological parameters

during stair ascent and descent, thereby enhancing mechanical efficiency and reducing task completion time. Weak negative correlation of weight with TUDS time indicates a slight tendency for heavier participants to demonstrate shorter completion times in the bivariate analysis. However, this relationship should be interpreted cautiously, as the association was weak and may be influenced by the concurrent effects of age and growth-related factors. These observations are consistent with earlier studies that reported similar associations between body dimensions and functional mobility tasks in paediatric populations [21,22].

The normative values observed in this study are comparable with previously reported TUDS reference values from other populations. Earlier study conducted in Hispanic children and ethnically diverse populations from the United States reported median TUDS completion times of approximately 6.0-6.2 seconds among participants aged 8-14 years. The values reported in the present study fall within a similar range, suggesting that stair-climbing performance in healthy children may demonstrate comparable patterns across different populations, although minor variations may occur due to influential environmental, cultural, and developmental factors [23,24]. The unchanged median values of pre- and post-test SpO_2 can be explained by the narrow physiological range observed in healthy school-aged children. Most participants had baseline SpO_2 values within the normal range (96-98%), and the TUDS test induced only minimal fluctuations that were insufficient to affect the median across the large sample. Additionally, pulse oximetry typically shows small variability (±1-2%) during brief functional activities, resulting in similar overall distributions despite minor individual changes.

Gender also showed a statistically significant association with TUDS scores (B=-0.840, β=-0.192, p-value <0.001), However, considering the weak negative correlation observed in the bivariate analysis, the clinical significance of this difference may be limited.

Body weight demonstrated a positive association with TUDS mean score, indicating that greater body weight was associated with longer stair-climbing times when controlling for other variables. This finding contrasts with the weak negative correlation observed in the univariate analysis, suggesting that the relationship between body weight and TUDS performance may be influenced by confounding growth-related variables such as age and height.

In contrast, height, lower limb length, and physiological variables measured before and after the TUDS test, including blood pressure, SpO_2, and HR, did not demonstrate significant independent contributions to TUDS performance (p-value >0.05).

Another important finding from this study was that physiological parameters such as HR, blood pressure, and SpO_2 established minimal clinical influence on TUDS performance. This finding suggests that the TUDS test primarily reflects functional mobility and motor efficiency rather than acute cardiopulmonary responses in healthy school-aged children. Consequently, anthropometric and maturational factors appear to play a more substantial role in determining stair-climbing ability within this age group. The primary aim of this study was to examine the association between TUDS performance and anthropometric and physiological parameters, rather than to assess pre-post changes. Physiological measures (HR, blood pressure, and SpO_2) were recorded mainly to monitor participant safety and immediate responses, and to explore their correlation with TUDS performance; therefore, pre-post comparative analysis was not included in the study design.

The discrepancy between correlation and regression findings reflects differences in analytical approaches. Spearman's correlation, a bivariate analysis, showed a weak negative association between body weight and TUDS performance, likely influenced by growth-related factors such as age, height, and limb length, as older children tend to be heavier and perform faster. In contrast, multivariate regression accounts for these confounders and demonstrated that higher body weight is associated with slightly longer TUDS time, suggesting increased mechanical demand during stair negotiation when growth effects are controlled [25].

The findings of this study have several clinical and research implications. Establishing normative reference values for TUDS performance in Indian school-aged children can assist clinical professionals, particularly physiotherapists and paediatric rehabilitation specialists, in identifying deviations from typical functional mobility. Such reference data may be useful for screening children with neuromuscular, orthopaedic, or developmental dysfunctions and for monitoring progress during rehabilitation interventions. Furthermore, the study highlights the importance of considering growth-related anthropometric characteristics when interpreting functional performance measures in paediatric populations.

Limitation(s)

Despite these contributions, several limitations should be acknowledged. First, the use of purposive sampling from a limited institutional setting may restrict the generalisability of the findings to the broader paediatric population. Second, potentially influential developmental variables such as nutritional status, level of physical activity, and pubertal stage were not assessed, which may influence functional performance during this period of rapid growth. Third, environmental factors, including stair dimensions, footwear, and participant motivation, were not strictly standardised and may have contributed to variability in performance. Future research should consider larger multicentric samples and include additional developmental and environmental variables to further refine normative reference values and improve the interpretability of TUDS performance in paediatric populations.

CONCLUSION(S)

This study evaluated the association between TUDS performance and anthropometric and physiological parameters, demonstrating that school-going participants are predominantly influenced by anthropometric parameters such as age, gender, and body weight, while physiological parameters exert minimal influence on stair climbing performance. These findings highlight the role of maturational and biomechanical factors in stair-climbing performance. The study also supports the clinical utility of the TUDS test as one of the reliable functional mobility outcome measures, and provide population-specific reference values to aid its interpretation in paediatric practice.

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