DOI: 10.7860/JCDR/2026/87906.23527

Original Article

Physiotherapy Section

Establishing Normative Values for Single Leg Hop Test in School-going Children Aged 8-15 years: A Cross-sectional Study from Haryana, India

JASMEET KAUR[1], MANU GOYAL[2], ARADHANA CHHABRA[3], KANU GOYAL[4]

ABSTRACT

Introduction: The Single Leg Hop Test (SLHT) is a functional tool used to evaluate unilateral lower limb power and dynamic stability in paediatric populations. Although, it is widely used in clinical and research settings, standardised reference ranges for school-going children are not well-established, limiting the ability of consistent interpretation of performance results.

Aim: To establish normative values for the SLHT among school going children aged 8-15 years.

Materials and Methods: A cross-sectional study was conducted at MM International School, Mullana, Ambala, Haryana, India from January 2025 to December 2025. This study included 330 school-going children aged between 8-15 years. Participants were stratified by age and gender. The test was conducted using standardised procedures, and hop distance was recorded as the primary outcome measure. Age and gender-specific reference ranges were established using descriptive statistics, including mean values, standard deviations, and percentile distributions to measure the changes in functional performance.

Results: A total of 330 school-going children aged 8-15 years were analysed. The mean distances of the single leg hop were 85.04±28.46 cm for the right leg and 81.83±29.66 cm for the left leg. Hop performance improved gradually with age ($p<0.001$). Females demonstrated slightly longer hop distances than males; however, the difference was not statistically significant, while higher Body Mass Index (BMI) showed lower hop performance outcomes ($p<0.05$). The children showed age-related improvements in lower-limb strength, balance, and functional ability. In addition, for the reliability testing of SLHT, another sample of 166 school-going children across different BMI categories was analysed. Excellent reliability was observed for both limbs, with Intraclass Correlation Coefficients (ICC) of 0.99 for right and left leg hop distances (95% CI: 0.987-0.996, $p<0.001$).

Conclusion: The present study provides age and gender-specific normative values for the SLHT in school-going children, reporting age-related improvements, slightly higher performance in females, and a mild negative influence of higher BMI, thus supporting its standardised use in paediatric functional assessment.

Keywords: Anterior cruciate ligament injuries, Body composition, Paediatric functional performance, Reference ranges, Return to sports

INTRODUCTION

Functional hop tests, such as the Single Leg Hop for Distance (SLHD), triple hop, and crossover hop, assess lower extremity muscle strength and the ability to perform tasks requiring dynamic knee stability. These tests are commonly used to monitor progress during knee rehabilitation programs [1,2], specifically after Anterior Cruciate Ligament Reconstruction (ACLR) [1]. Previous literature showed significant associations between hop performance and physical impairments such as muscle weakness, increased passive joint laxity, and deficits in knee joint proprioception [2].

Structural changes associated with ACL injuries have also been reported; for instance, bone bruises are found in a high proportion of paediatric ACL injuries [3]. The distance covered in the SLHD reflects the overall work done by the kinetic chain during the propulsion phase of the leg, specifically at the hip, knee, and ankle. This work must be managed throughout the landing phase, and distance, balance, and stability are analysed after the test, which may reveal the knee stability, which help identify deficits and determine the effectiveness of any rehabilitation intervention [1,2].

Assessment of physical-functional status plays a key role in identifying individuals at higher risk of injury. The test serves as a foundation for designing a conditioning program to prevent injury as well as monitoring the recovery. It assists in predicting the risk of lower limb injuries, tracking functional improvements, and guiding return-to-sport decision-making for the athletes [4].

Motor skill development in children is affected by task difficulty, environmental factors, and individual traits. Obesity can make activities more challenging, leading to reduced physical activity [5]. Walking is the first locomotion skill, begins with toddlers exhibiting wide stances and outward toes, gradually progressing to a more aligned posture. With increasing age, walking speed and step length increases, with joint kinematics becoming more consistent by around three-year-old. By age of seven, nearly 60% can hop on one leg, but “mature hopping” is typically achieved by age five, with full mastery often not reached until approximately 10-year-old [6-8].

Age, gender, and BMI can influence lower limb performance in children due to ongoing growth and developmental variations. Assessing hop performance across these factors helps in improving interpretation and understanding functional differences in paediatric populations. However, current literature provides limited evidence on normative values of SLHT [3,6,9-11] and its reliability in healthy children while considering variations in body composition. Therefore, the existing research gap indicates the need for further research on normative values and reliability measures to improve the interpretation of SLHT performance in children.

So, the present study aimed to establish age and gender specific reference values, relative and absolute reliability of the SLHT in normal, overweight, and obese children. The objectives of the study are to evaluate single leg hop performance in school-going children aged 8-15 years, to analyse variations in hop distance across different age groups and between genders, and to establish normative values for clinical and functional assessment in normal, overweight, and obese children.

MATERIALS AND METHODS

A cross-sectional study was conducted at MM International School, Mullana, Ambala, Haryana, India from January 2025 to December 2025. Ethical approval for the study was obtained from the Institutional Ethical Committee (IEC no.: 3088) of Maharishi Markandeshwar Institute of Medical Sciences and Research (MMIMSR) of Maharishi Markandeshwar (Deemed to be) University Mullana, Ambala, Haryana, India. The study was conducted in accordance with Helsinki Declaration revised in 2013 and National Ethical Guidelines for Biomedical Research involving Human Participants, 2017.

Inclusion and Exclusion criteria: In the study, both male and female school-going children between the age of 8 and 15 years who were able to follow verbal instructions were included. Children receiving medications that could affect balance, those unwilling to perform the test procedures, or those with known musculoskeletal injuries, recent fractures, neurodevelopmental or neuromotor disorders, severe visual impairments, myocardial infarction, or any other medical conditions that could influence balance, muscle strength, or functional performance were excluded. Non-cooperative participants were also excluded from the study. Underweight children (<5th percentile) were excluded to avoid the influence of undernutrition on functional performance outcomes.

Sample size calculation: School-going children of 8-15 years of age were recruited for the study using purposive sampling. The sample size was calculated using the Cochran's formula

$n=(Z^2 \times P \times q)/e^2$,

where the Z value was 1.96. The expected proportion (P) was assumed to be 70% based on previous literature reporting functional performance outcomes in hop testing among children [10]. The value of q was calculated as (100-P), and the error margin (e) was set at 0.05. The estimated sample size was 323 and was adjusted to 330 participants for the precision and reliability of the reference values.

Data collection was performed using standardised materials and equipment, including a measuring tape and floor tape for marking distances, a weighing machine, a stadiometer, a stopwatch, a pen, paper, and a scale. Anthropometric measurements, including age (years), weight (kg), height (cm), and BMI (kg/m^2), were recorded before testing. The primary outcome measure was hop distance, with the additional functional observations of balance and stability during test performance. All assessments were conducted by following the standardised testing protocols for ensuring consistency and reliability of the measurements.

Study Procedure

The permission was taken from the school principal to conduct the research within the school premises. To invite participation, local announcements were made targeting students aged 8 to 15, encouraging their involvement in the study. Once students express interest, they were given an assent form, and their parents were provided with an informed consent form that outlines the study's objectives and procedures.

The SLHT procedure involved several steps. After participants were informed about the study and demonstrated all the equipment s, their questions were answered before they sign the consent form. Each participant was given a unique reference number, and demographic information, including age, height, weight and gender was collected with neurological or neurodevelopmental conditions, the number of medications currently being taken, and a history of fall-related injuries, if any. Participants were categorised according to BMI into three groups: Normal weight (BMI between the 5th and 85th percentiles), Overweight (BMI between the 85th and 95th percentiles), and Obese (BMI equal to or greater than the 95th percentile) [12].

Administration of the Test:

The SLHT was performed according to previously described standardised procedures [3].

1. A SLHT was performed on both legs by the participants.
2. Distance of the hop was measured with the use of measuring tape starting from the line marked from big toe of the tested leg to heel after landing.
3. Three hops were allowed as practice, followed by three test attempts with a rest interval of 60 seconds between them. Best of three attempts was considered.
4. A successful hop was defined as hopping and landing on the same leg maintaining the stability for at least 3 seconds.
5. Participants were free to move their arms during the test, and no specific jumping techniques were instructed to minimise bias.

To determine the test–retest reliability, a separate sample of 166 participants was recruited in addition to the normative sample. Participants were then categorised into normal weight (n=54), overweight (n=56), and obese (n=56) groups. Prior research has demonstrated that approximately 50 participants are needed to provide stable estimates of reliability [13]. All assessments were taken by single trained assessor and were repeated after 48 hours so as to minimise recall bias and physiological changes of each participant between measurements [14].

After testing one leg, participants repeated the procedure with the other leg. Participants were allowed maximum three jump attempts in full stability 3s after landing. If during landing the participant touched the ground with the other leg, the attempt was considered unsuccessful. The test was conducted during the morning hours to avoid the potential influence of fatigue. Participants were asked to perform the tests barefoot to prevent variability in performance due to differences in footwear. No specific instructions were given for warm up before testing in order to maintain the consistency across participants. The test was performed on a flat indoor surface under similar environmental conditions.

Participant safety and comfort was prioritised throughout the study and any confounding factors that could impact the results were considered. This structured approach was intended to maintain the reliability and validity of the results and to contribute valuable evidence into the physical performance of school-aged children.

STATISTICAL ANALYSIS

The data analysis was done with Statistical Package for Social Sciences (SPSS) software, version 26.0. Kolmogorov-Smirnov test was applied for assessing the normality as the estimated sample size was 330. The descriptive statistics used One -way Analysis of Variance (ANOVA) and was presented as Mean± Standard Deviation (SD) as the data is normally distributed. A linear regression model was applied to develop predictive equations. Test-retest reliability was assessed using ICC, while absolute reliability was evaluated using the Standard Error of Measurement (SEM) and Minimal Detectable Change (MDC). The data analysis for agreement between measurements was represented with Bland-Altman plots and scatter plots were used for graphical representation.

RESULTS

A study of 330 school-going children between the age of 8 and 15 years was done to establish the normative values of SLHT. The mean age of the study participants were 10.71±1.84 years [Table/Fig-1]. There were 201 males and 129 females in this study.

Normality testing using the Kolmogorov-Smirnov test showed normal distributed of the hop distance data (p>0.05). Therefore, parametric tests were applied for further analysis. Descriptive statistics of the demographic and anthropometric characteristics of the participants presented in show normal distribution [Table/Fig-1].

Variables	Mean±SD
Age (years)	10.71±1.84
Weight (kg)	49.86±12.98
Height (cm)	141.58±11.34
BMI (kg/m^2)	24.76±5.20

[Table/Fig-1]: Descriptive characteristics of the participants.

Reference ranges for the SLHT in [Table/Fig-2] demonstrated a progressive increase in hop distance with age. For the right leg, the mean hop distance increased from 74.19±25.96 cm in the 8-9 years age group to 107.10±27.15 cm in the 14-15 years age group, indicating consistent age-related improvements in lower limb functional performance.

Age group (years)	Right leg hop distance (cm) Mean±SD	Left leg hop distance (cm) Mean±SD
8-9	74.19±25.96	70.96±25.32
10-11	81.13±26.32	77.63±28.45
12-13	96.00±27.49	92.40±27.02
14-15	107.10±27.15	106.28±33.09
Overall	85.04±28.46	81.83±29.66

[Table/Fig-2]: Age-specific reference values of single leg hop distance (right and left legs).
*One-way ANOVA showed a statistically significant difference in hop distance across age groups for both the right and left legs (p<0.001)

Similarly, the left leg hop distance improved from 70.96±25.32 cm to 106.28±33.09 cm across the same age groups demonstrating marginally higher hop distances compared to the right leg. *One-way ANOVA showed a statistically significant difference in hop distance across age groups for both the right and left legs (p<0.001).

Comparison of hop performance demonstrated female participants with slightly higher mean hop distances than males for both limbs is presented in [Table/Fig-3]. The mean right leg hop distance in females was 87.16±28.14 cm that was higher compared to 83.68±28.64 cm in males. Similarly, the mean left leg hop distance was 84.87±28.58 cm in females and 79.88±30.25 cm in males. These findings suggest marginally better hop performance among female participants in the studied age group. However, Independent samples t-test showed no statistically significant difference in hop distance between females and males for both the right (p=0.278) and left legs (p=0.136).

Gender	Right leg hop distance (cm) Mean±SD	Left leg hop distance (cm) Mean±SD
Female	87.16±28.14	84.87±28.58
Male	83.68±28.64	79.88±30.25

[Table/Fig-3]: Gender-specific reference values of Single Leg Hop Distance (SLHD).
*Independent samples t-test showed no statistically significant difference in hop distance between females and males for both the right (p=0.278) and left legs (p=0.136). n=330 (Females=129, Males=201)

Hop performance across BMI categories in [Table/Fig-4] showed that children in the normal BMI category demonstrated the highest hop distances for both the right (95.58±22.56 cm) and left (94.00±30.26 cm) legs. Participants in overweight category showed comparatively lower hop distances, while the obese category exhibited the lowest mean hop distances for both limbs. This represented an inverse trend between hop performances with BMI category which revealed a statistically significant difference in hop distance across BMI categories for both the right (p=0.023) and left legs (p=0.014).

BMI category	Right leg hop distance (cm) Mean±SD	Left leg hop distance (cm) Mean±SD
Normal	95.58±22.56	94±30.26
Overweight	85.29±28.11	81.02±27
Obese	82.17±29.72	79.34±30.96

[Table/Fig-4]: Reference values of single leg hop distance based on BMI category.
*One-way ANOVA revealed a statistically significant difference in hop distance across BMI categories for both the right (p=0.023) and left legs (p=0.014)

Multiple linear regression analysis was performed to examine the influence of age, weight, height, BMI, and gender on single leg hop performance. The regression model was statistically significant for both the right leg (R^2=0.199, F=16.087, p<0.001) and the left leg (R^2=0.188, F=15.033, p<0.001). Age was a significant predictor of hop performance for both limbs (p<0.001). Height (B=-1.706, p=0.003) and BMI (B=-3.642, p=0.024) demonstrated a significant inverse relationship with hop distance. Weight (B=1.516, p=0.053) showed a borderline positive relationship in the model, while gender was not found to be a significant predictor of hop performance (right: p=0.580; left=0.268).

Although height showed a significant negative coefficient in the regression model, this finding appeared counterintuitive from a clinical perspective. However, collinearity diagnostics showed high Variance Inflation Factor (VIF) values for height, weight, and BMI, indicating multicollinearity among growth-related variables included in the model. These variables were retained in the model to examine their combined influence on hop performance.

Based on the regression analysis, predictive equations were derived as follows:

Right leg hop distance (cm):

Hop distance= 253.106+8.468 (age)+1.516 (weight)-1.706 (height)-3.642 (BMI)-1.648 (gender)

Left leg hop distance (cm):

Hop distance=247.403+8.338 (age)+1.604 (weight)-1.689 (height)-3.640 (BMI)-3.457 (gender)

*Gender was coded as 1= female and 2= male.

In addition, for the reliability testing of SLHT, another sample of 166 school-going children across different BMI categories were analysed. Test-retest difference scores showed normal distribution (RtDiff p=0.545; LtDiff p=0.576). Excellent reliability was observed for both limbs, with ICCs of 0.99 for right and left leg hop distances (95% CI: 0.987-0.996, p<0.001). A Cronbach's alpha of 0.995 indicated high internal consistency. The findings presented in [Table/Fig-5] indicate minimal measurement error and high consistency of the SLHT across repeated measurements. The SEM values were 2.39 cm for the right limb and 2.29 cm for the left limb, while the MDC values were 7.24 cm and 6.35 cm, respectively, indicating minimal measurement error [Table/Fig-5].

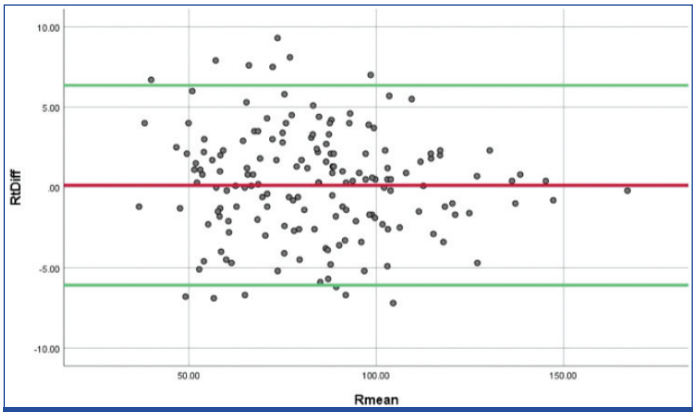
Variables	Test (cm)	Retest (cm)	ICC (95% CI)	SEM (cm)	MDC (cm)
Right leg	83.61±23.96	83.88±23.69	0.99	2.39	7.24
Left leg	82.59±22.93	82.72±23.02	0.99	2.29	6.35

[Table/Fig-5]: Test-retest reliability of the Single Leg Hop Test (SLHT).
Values are expressed in Mean±SD.

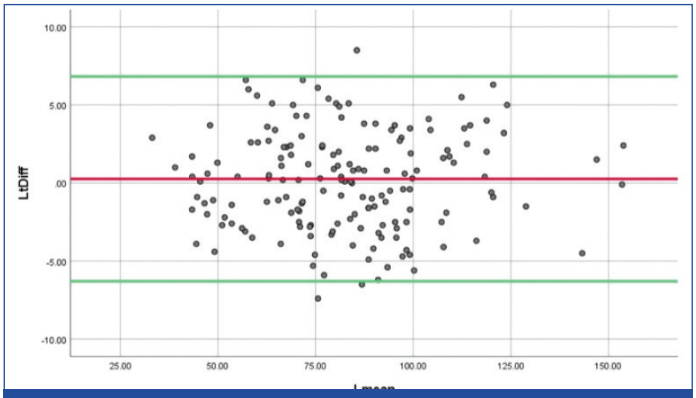
For the evaluation of systematic bias between test and retest measurements, paired sample and one-sample t-tests were performed. Paired sample t-test demonstrated the absence of a statistically significant difference between test and retest scores for the right limb (p=0.313) or the left limb (p=0.581). One-

sample t-test also confirmed that mean difference scores did not show a statistically significant difference between test and retest measurements for either limb (right: p=0.313; left: p=0.581), thus indicating the absence of systematic error.

Bland-Altman plots were constructed to evaluate agreement between test and retest measurements for both limbs. The Bland-Altman plot for the right limb is presented in [Table/Fig-6], whereas the corresponding plot for the left limb is shown in [Table/Fig-7]. The plots demonstrated that the most data points were distributed within the 95% limits of agreement, indicating good agreement between test and retest measurements with no evidence of systematic bias. Simple linear regression revealed no significant relationship between mean SLHT performance and test-retest difference scores.



[Table/Fig-6]: Bland-Altman plot showing agreement between test and retest Single Leg Hop Test (SLHT) scores for the right limb.



[Table/Fig-7]: Bland-Altman plot showing agreement between test and retest Single Leg Hop Test (SLHT) scores for the left limb.

DISCUSSION

The present study established age, gender and BMI-specific reference values for the SLHT in school-going children aged 8-15 years and evaluated the test-retest reliability of this functional performance measure. The data showed an evident age-related increase in hop distance for both limbs, with progressive improvement from younger to older age groups. Recent evidence indicates that age-related improvements in hop performance occur not only due to increases in muscle mass but also by neuromuscular adaptations that enhance motor unit recruitment and dynamic muscle control during growth [15]. This suggests growth-related changes in muscle strength, neuromuscular coordination and motor control during childhood and early adolescence. Similar results have been consistently reported in hop performance in previous researches in paediatric population, where hop distance increased progressively with age due to improvements in strength, coordination, and neuromuscular maturation [10,16]. This supports the clinical relevance and validity of the reference values established in the present study.

Although, gender analysis demonstrated marginally higher hop distances among female participants, this difference was not statistically significant. Previous studies in older adolescent populations often report greater lower-limb power in males due to pubertal increases in muscle mass and strength [4,10,17]. However, in pre-adolescent and early adolescent age groups, gender-based differences in hop performance are generally minimal [5,18]. These findings are often supported by differences in biological maturation related neuromuscular development rather than true gender-related disparities in strength or power [19,20]. Therefore, current study demonstrates the significance of interpreting hop performance primarily with age-specific reference ranges and not only relying on comparisons by gender alone in younger population.

Analysis based on BMI categories revealed that children with normal BMI demonstrated the highest hop distances, whereas performance was lowered in overweight and obese participants progressively. Children with higher BMI tended to have lower hop distances, which has also been reported in previous studies that indicates the increased mechanical demands placed on lower limb during lower limb tasks such as hopping, can diminish movement efficiency and functional performance [21,22]. These findings highlight that body composition should be considered while interpreting the outcomes of functional performance in children.

Moreover, the study exhibited excellent test-retest reliability of the SLHT confirming its consistency and clinical applicability. ICCs of approximately 0.99 for both limbs indicate very high relative reliability, which indicate comparable and consistent values reported in earlier studies of single leg hop performance tests in paediatric and sports rehabilitation settings [9,23]. High internal consistency further supports the stability of the measure. Primarily, the low and acceptable values of SEM and MDC, respectively suggest that changes exceeding the MDC can be interpreted as true changes in performance rather than error variations in measurement. The test and retest measurements showed absence of significant differences between them and Bland-Altman analysis also exhibited good agreement and no proportional bias, therefore supporting the robustness of the SLHT for repeated measures.

The present findings show that the SLHT provides consistent and reproducible measurements along with clinically meaningful reference values in school-going children. The use of age, gender and BMI-specific reference ranges, together with MDC thresholds, allows for precise and accurate interpretation of functional performance by the outcomes of SLHT and true changes in it over time. The results of this investigation support the use of this test as a reliable measure for functional assessment and long term monitoring of performance changes in paediatric clinical and research settings.

Clinically, the existence of normative data for age-specific populations will help physiotherapist/clinicians in identifying children with reduced functional capability of the lower limbs and monitor their rehabilitation progress following injury to the lower limb. Normative values may also facilitate the functional assessment of school-aged children and help to identify their limitations in strength, balance, and neuromuscular control within the lower limb. Furthermore, the reference ranges established in this study may assist in the evidence-based decision-making for returning a child to activity or sport and help to evaluate changes in function over time through paediatric rehabilitation programs. Standardised reference values for hop performance may facilitate the objective evaluation of functional performance as well as aid clinicians and researchers in evaluating rehabilitation or training programs that are designed to improve lower limb function in children.

Limitation(s)

There are certain limitations of the present study that must be taken into consideration while interpreting the results. The data was collected from school-aged children of the same geographical area, which may limit generalisability of the findings to other populations. Furthermore, although participants were classified by BMI, there were no measures assessed on body composition such as muscle

mass or fat percentage. Due to the cross-sectional design of this research, the ability to assess any developmental changes in hop performance over a period of time was limited.

Future longitudinal studies with larger and more diverse samples may allow for the better understanding of how functional performance for hop change throughout the growth and development process.

CONCLUSION(S)

The hop distances demonstrated consistent improvements with increase in age, whereas increased BMI was associated with mild decrease in hop capacity. The present study established normative values of SLHT that enhance the accuracy for interpretation of performance for the same and support its standardised use in paediatric functional assessment. The SLHT also demonstrated excellent test-retest reliability with very high ICCs, indicating strong measurement consistency. Therefore, the test can be considered as an effective and reliable tool for assessment of functional performance of lower limb in children. The normative data may provide useful information for screening of functional performance and monitor the changes during in it throughout the process of growth and rehabilitation.

REFERENCES

[1] Kotsifaki A, Whiteley R, Van Rossom S, Korakakis V, Bahr R, Sideris V, et al. Single leg hop for distance symmetry masks lower limb biomechanics: Time to discuss hop distance as decision criterion for return to sport after ACL reconstruction? Br J Sports Med. 2022;56(5):249-56. Doi: 10.1136/bjsports-2020-103677.

[2] Fitzgerald GK, Lephart SM, Hwang JH, Wainner RS. Hop tests as predictors of dynamic knee stability. J Orthop Sports Phys Ther. 2001;31(10):588-97. Doi: 10.2519/jospt.2001.31.10.588. PMID: 11665746.

[3] Almalki H, Herrington L, Jones R. Normative values for single-leg hop performance in Saudi healthy population. Saudi Journal of Sports Medicine. 2021;21(3):87. Doi: 10.4103/sjsm.sjsm_23_21

[4] Dominguez-Navarro F, Casaña J, Perez-Dominguez B, Ricart-Luna B, Cotolí-Suárez P, Calatayud J. Dynamic balance and explosive strength appears to better explain single leg hop test results among young elite female basketball athletes. Sci Rep. 2023;13(1). Doi: 10.1038/s41598-023-31178-7 PubMed PMID: 37016001.

[5] Kakebeeke TH, Lanzi S, Zysset AE, Arhab A, Messerli-Bürgy N, Stuelb K, et al. Association between body composition and motor performance in preschool children. Obes Facts. 2017;10(5):420-31. Doi: 10.1159/000477406 PubMed PMID: 28934745.

[6] Holm I, Tveter AT, Fredriksen PM, Vøllestad N. A normative sample of gait and hopping on one leg parameters in children 7-12 years of age. Gait Posture. 2009;29(2):317-21. Doi: 10.1016/j.gaitpost.2008.09.016 PubMed PMID: 19019681.

[7] Gabbard CP. Lifelong motor development. 6th ed. Boston: Pearson; 2012.

[8] Roberton MA, Halverson LE. Developing Children: Their Changing Movement: A Guide for Teachers. Philadelphia: Lea & Febiger; 1984.

[9] Magill JR, Myers HS, Lentz TA, Pietrosimone L, Risoli T, Green CL, et al. Establishing age- and sex-specific norms for pediatric return-to-sports physical performance testing. Orthop J Sports Med. 2021;9(8):23259671211023101. Doi: 10.1177/23259671211023101.

[10] Warming S, Alkjær T, Herzog RB, Lundgaard-Nielsen M, Zebis MK. Reference data for hop tests used in pediatric ACL injury rehabilitation: A cross-sectional study of healthy children. Scand J Med Sci Sports. 2021;31(9):1832-39. Doi: 10.1111/sms.13986 PubMed PMID: 33963610.

[11] Schneiders AG, Sullivan SJ, Gray AR, Hammond-Tooke GD, McCrory PR. Normative values for three clinical measures of motor performance used in the neurological assessment of sports concussion. J Sci Med Sport. 2010;13(2):196-201. Doi: 10.1016/j.jsams.2009.05.004 PubMed PMID: 19560971.

[12] Ogden CL, Freedman DS, Hales CM. CDC extended BMI-for-age percentiles versus percent of the 95th percentile. Pediatrics. 2023;152(3):e2023062285. Doi: 10.1542/peds.2023-062285 PubMed PMID: 37615069.

[13] Han O, Tan HW, Julious S, Sutton L, Jacques R, Lee E, et al. A descriptive study of samples sizes used in agreement studies published in the PubMed repository. BMC Med Res Methodol. 2022;22(1):242. Doi: 10.1186/s12874-022-01723-5 PubMed PMID: 36123642.

[14] Vijayakumar M, Palekar TJ. Estimating the reliability and validity of the quadrant hop test in the assessment of the functional stability of the knee. Cureus. 2024 May 17. Doi: 10.7759/cureus.60516.

[15] Enomoto S, Tottori N. Muscle morphological adaptations to resistance training and sports participation in children and adolescents: A scoping review. Frontiers in Sports and Active Living. Frontiers Media SA; 2025. Doi: 10.3389/fspor.2025.1646835.

[16] Alkjaer T, Zebis MK, Herzog RB, Lundgaard-Nielsen M, Skovgaard LT, Krogsgaard MR, et al. Evaluation of hop performance in children with anterior cruciate ligament reconstruction using healthy reference data: A cross-sectional study. Knee. 2023;42:19-27. Doi: 10.1016/j.knee.2023.02.007 PubMed PMID: 36863117.

[17] Koźlenia D, Popowczak M, Szafraniec R, Alvarez C, Domaradzki J. Changes in muscle mass and strength in adolescents following high-intensity functional training with bodyweight resistance exercises in physical education lessons. J Clin Med. 2024;13(12):3400. Doi: 10.3390/jcm13123400

[18] Petrić V, Ljubičić S, Novak D. Normative data for vertical jump tests in pre-school children aged 3 to 6 years. Biomechanics (Switzerland). 2025;5(3):56. Doi: 10.3390/biomechanics5030056.

[19] Schmitt LC, Brunst C, Ithurburn M, Ilardi D, Thomas S, Huang B, et al. Identification and predictors of age-relevant and activity-relevant hop test targets in young athletes after anterior cruciate ligament reconstruction. J Athl Train. 2022;57(9-10):946-54. Doi: 10.4085/1062-6050-0636.21 PubMed PMID: 36638339.

[20] Greenberg EM, Dyke J, Leung A, Karl M, Lawrence JT, Ganley T. Uninjured youth athlete performance on single-leg hop testing: How many can achieve recommended return-to-sport criterion? Sports Health. 2020;12(6):552-58. Doi: 10.1177/1941738120911662 PubMed PMID: 32392085.

[21] Manzano-Carrasco S, Garcia-Unanue J, Haapala EA, Felipe JL, Gallardo L, Lopez-Fernandez J. Relationships of BMI, muscle-to-fat ratio, and handgrip strength-to-BMI ratio to physical fitness in Spanish children and adolescents. Eur J Pediatr. 2023;182(5):2345-57. Doi: 10.1007/s00431-023-04887-4 PubMed PMID: 36881145.

[22] Ross MD, Langford B, Whelan PJ. Test-retest reliability of 4 single-leg horizontal hop tests. national strength & conditioning association J. Strength Cond. Res [Internet]. 2002. Report. Available from: http://journals.lww.com/nsca-jscr.

[23] Sawle L, Freeman J, Marsden J. Intra-rater reliability of the multiple single-leg hop-stabilization test and relationships with age, leg dominance and training. Int J Sports Phys Ther. 2017;12(2):190-98. Doi: 10.26603/ijspt20170190.

PARTICULARS OF CONTRIBUTORS:

1. Postgraduate Student, MM Institute of Physiotherapy and Rehabilitation, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana, India.
2. Professor, MM Institute of Physiotherapy and Rehabilitation, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana, India.
3. Postgraduate Student, MM Institute of Physiotherapy and Rehabilitation, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana, India.
4. Assistant Professor, MM Institute of Physiotherapy and Rehabilitation, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Kanu Goyal,
Assistant Professor, MM Institute of Physiotherapy and Rehabilitation,
Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala,
Haryana-133207, India.
E-mail: kanu.goyal@mmumullana.org

PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Feb 10, 2026
- Manual Googling: Apr 06, 2026
- iThenticate Software: Apr 08, 2026 (4%)

ETYMOLOGY: Author Origin

EMENDATIONS: 8

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Feb 02, 2026**
Date of Peer Review: **Feb 24, 2026**
Date of Acceptance: **Apr 10, 2026**
Date of Publishing: **Jun 01, 2026**