

Six-minute walk test performance among school children aged 7-12 years living above 2300 meters in Jumla, Nepal

Kamal Prasad Thani¹, Sandeep Shrestha¹, Uttara Gautam¹, Munna Keshari¹, Subash Sharma², Amare Hailu Ashine³

¹Department of Paediatrics, Karnali Academy of Health Sciences, Jumla, Nepal

²Department of Pediatrics, Karnali Provincial Hospital, Surkhet, Nepal

³Department of Internal Medicine, Jimma University, Ethiopia

ABSTRACT

Introduction: The Six-Minute Walk Test (6MWT) is a practical and widely used measure of submaximal functional exercise capacity. There are limited studies conducted in high altitude regions, particularly among children from hilly areas.

Methods: A cross-sectional study was conducted among healthy school children in Jumla at altitudes ranging from 2,300 to 2,900 meters. Anthropometric data (height, weight, BMI) were recorded. The 6MWT was performed according to the American Thoracic Society (ATS) guidelines. Pre- and post-test heart rate, oxygen saturation (SpO₂), and perceived exertion (modified Borg scale) were measured.

Results: A total of 120 children (60 boys, 60 girls) were included. The mean 6MWD was 585 ± 42 meters. Boys walked slightly farther than girls, but this difference was not statistically significant (p = 0.068). Height and age showed a strong positive correlation with 6MWD (both p < 0.001). Baseline SpO₂ was lower than sea-level norms (mean 94.2%), demonstrating high-altitude acclimatization, with a slight, non-pathological desaturation post-exercise.

Conclusion: This study provides preliminary reference values for the 6MWT in children residing at high-altitude in Jumla, Nepal. Anthropometric factors, particularly height and age, are primary determinants of walking distance in this population.

Keywords: Children, Functional Capacity, High Altitude, Jumla, Nepal, Six-Minute Walk Test

INTRODUCTION

The Six-Minute Walk Test (6MWT) is a standardized, well-tolerated, and inexpensive tool used to assess submaximal functional exercise capacity.¹ It reflects the physiological response of the cardiopulmonary and musculoskeletal systems to physical stress.² In pediatric populations, the 6MWT is widely utilized to monitor disease progression and treatment efficacy in conditions such as cystic fibrosis, congenital heart disease, and severe asthma.^{3,4}

To accurately interpret 6MWT results in a clinical setting, population-specific reference values are essential. Various studies have established normative data for children in different regions of the world, including Asia, North America, and Europe.⁵⁻⁸ However, physiological responses to exercise are significantly influenced by environmental factors, particularly by altitude.⁹

High altitude environments expose residents to chronic hypobaric hypoxia, leading to distinct physiological adaptations such as reduced baseline oxygen saturation, increased hemoglobin concentration, and altered ventilatory response.^{10,11} Jumla is situated in the Karnali Province of Nepal and has an elevation between 2,500 and 2,900 meters. Children born and raised in this region possess physiological adaptations that

may influence their functional exercise capacity compared to lowland populations.¹²

Currently, there is limited data on normative 6MWT performance among Nepalese children, particularly those residing in high-altitude regions like Jumla. Therefore, this study aims to establish normative values for the 6MWT in healthy children aged 7 to 12 years in Jumla, Nepal, and to investigate the influence of age, gender, and anthropometric variables on their performance.

METHODS

A cross-sectional, school-based study was conducted in Jumla district, Karnali Province, Nepal. Ethical approval was obtained from the Institutional Review Committee (IRC) of the Karnali Academy of Health Sciences prior to the study. Written informed consent was obtained from parents or guardians, and verbal assent was taken from the children.

Healthy children aged 7 to 12 years attending local schools were recruited using convenience sampling. Inclusion criteria included lifelong residents of Jumla and absence of acute illness in the past 4 weeks. Exclusion criteria included chronic cardiopulmonary disease, neuromuscular disorders, recent lower limb injury, or inability to follow instructions. Height was measured to the nearest 0.1 cm using a portable stadiometer (Seca 213, Seca GmbH & Co. KG, Hamburg, Germany). Weight was measured to the nearest 0.1 kg using a digital weighing scale (Microlife WS 50, Microlife AG, Switzerland). Body Mass Index (BMI) was calculated.

The 6MWT was conducted following the American Thoracic Society (ATS) guidelines¹ in a flat, straight, enclosed 30-meter school corridor. Children were instructed to walk as far as possible in six minutes without running. Standardized encouragement was provided every minute. Heart rate (HR) and oxygen saturation (SpO₂) were measured before and after the test using a fingertip pulse oximeter (Microlife OXY 200, Microlife AG, Switzerland). Perceived exertion was assessed using a modified pediatric Borg scale (0-10) before and after the test.¹³

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Corresponding Author:
Dr. Kamal Prasad Thani
Email: kamalthani@gmail.com

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Data were analyzed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed as mean \pm standard deviation (SD). An independent t-test was used to compare variables between genders. Pearson correlation coefficients were calculated to assess the relationship between 6MWD and anthropometric variables. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 120 children (60 boys, 60 girls) completed the study. The anthropometric characteristics were summarized (Table 1). There were no statistically significant differences between boys and girls across baseline variables (all $p > 0.05$).

Table 1: Anthropometric characteristics of the study population (N=120)

Variable	Total (n=120)	Boys (n=60)	Girls (n=60)	p-value
Age (years)	9.5 \pm 1.6	9.6 \pm 1.5	9.4 \pm 1.7	0.45
Height (cm)	132.4 \pm 10.2	133.1 \pm 10.5	131.7 \pm 9.8	0.32
Weight (kg)	28.5 \pm 5.4	29.1 \pm 5.6	27.9 \pm 5.1	0.28
BMI (kg/m ²)	16.1 \pm 1.8	16.3 \pm 1.9	15.9 \pm 1.7	0.31

Values are expressed as Mean \pm SD.

The mean 6MWD for the entire cohort was 585 \pm 42 meters (Table 2). Boys walked slightly farther than girls (592 \pm 45m vs. 578 \pm 38m), but this difference did not reach statistical significance ($p = 0.068$). The mean heart rate increased from 88 \pm 12 bpm before the test to 135 \pm 18 bpm after the test, while the Borg scale increased from 0.2 \pm 0.4 to 3.5 \pm 1.2, indicating an appropriate physiological response to exercise in this cohort. Baseline SpO₂ was 94.2 \pm 1.5%, consistent with high-altitude acclimatization. Post-exercise SpO₂ decreased slightly to 92.8 \pm 1.8%, with a mean decline of 1.4 \pm 0.8%.

Table 2: Physiological parameters and 6MWT outcomes

Variable	Pre-Test	Post-Test	Change (Δ)
Heart Rate (bpm)	88 \pm 12	135 \pm 18	+47 \pm 15
SpO ₂ (%)	94.2 \pm 1.5	92.8 \pm 1.8	-1.4 \pm 0.8
Borg Scale (0-10)	0.2 \pm 0.4	3.5 \pm 1.2	+3.3 \pm 1.1
6MWD (meters)	-	585 \pm 42	-

Pearson correlation analysis revealed that height ($r = 0.62$, $p < 0.001$) and age ($r = 0.58$, $p < 0.001$) were the strongest positive predictors of 6MWD.

DISCUSSION

Published data on 6MWT performance among Nepalese children residing at high altitude are limited; therefore, this study provides preliminary reference values for the 6MWT in healthy children residing at high altitudes in Jumla, Nepal. The mean 6MWD achieved by our cohort (585 \pm 42 m) provides a baseline for evaluating functional capacity in this unique demographic.

The mean distance observed in our study is comparable to, though slightly lower than, values reported in some lowland pediatric populations. For instance, Lammers et al.⁵ reported a mean distance of 612 m in British children, and Priesnitz et al.⁶ reported 603 m in Brazilian children. The slightly lower distance in Jumla children is likely attributable to the lower partial pressure of oxygen at high altitudes, which limits maximum aerobic capacity.¹⁴ However, these children still demonstrate robust functional capacity, likely due to chronic hypoxic adaptation, which includes increased capillary density and optimized tissue oxygen extraction.¹⁵

A critical finding in our study is the baseline SpO₂ (94.2%). At sea level,

healthy children typically present with an SpO₂ of $\geq 98\%$. The observed resting desaturation is a hallmark of high-altitude residency and represents a normal physiological state for this population.¹⁶ During the 6MWT, a minor transient drop in SpO₂ (mean drop of 1.4%) was observed. Unlike in sea-level populations where exercise-induced desaturation often indicates pulmonary pathology, minor desaturation during exertion at high altitude is a common physiological consequence of diffusion limitations under hypobaric conditions.^{17,18}

Consistent with global literature, anthropometric factors, specifically height and age, were the strongest determinants of 6MWD.^{7,8} Taller children possess longer stride lengths, making them mechanically more efficient. The progression of muscle mass development and motor coordination with age also directly contributes to increased walking distances.¹⁹ While boys walked marginally farther than girls, the difference was not statistically significant in this pre-pubertal to early-pubertal age group, which aligns with findings by Geiger et al.⁸

From a public health perspective, these findings are useful for high-altitude districts where pediatric functional assessment is often interpreted using sea-level reference values. Locally derived 6MWT data can help clinicians, school health programs, and outreach teams distinguish expected altitude-related physiological responses from potential cardiopulmonary limitations. In resource-limited settings such as Karnali, this may improve screening, referral decisions, and follow-up of children with suspected chronic respiratory or cardiac disease, while also supporting future school-based health assessments and regional pediatric surveillance strategies.

This study has several limitations. First, the sample was obtained using a convenience sampling method from selected schools in a single district, which limits representativeness and generalizability to all children living at high altitude in Nepal. Second, the sample size, although adequate for preliminary analysis, may have been underpowered to detect small subgroup differences, particularly sex-based differences in walking distance. Third, potentially relevant determinants such as pubertal status, hemoglobin level, nutritional status beyond BMI, habitual physical activity, and socioeconomic differences were not assessed. Fourth, a practice walk test was not reported, and this may have influenced performance because familiarity with the 6MWT can affect distance achieved. Finally, the study did not generate a multivariable prediction equation, so the findings should be interpreted as preliminary normative data rather than definitive reference standards. Larger multicenter studies across diverse high-altitude regions of Nepal are needed to develop robust reference equations and improve external validity.

CONCLUSION

This study establishes preliminary reference values for the 6MWT in children aged 7-12 years residing in the high-altitude region of Jumla, Nepal. The findings highlight that while these children exhibit lower baseline oxygen saturation due to altitude acclimatization, they maintain excellent submaximal functional capacity. Height and age remain the primary determinants of walking distance. These local reference values may be useful for clinicians at the Karnali Academy of Health Sciences and similar high-altitude centers to accurately assess pediatric cardiopulmonary diseases.

DECLARATIONS

Author Contributions

KPT was involved in all stages of the research, including concept and design, literature review, data collection, analysis, interpretation, and manuscript preparation. SS contributed to data collection and analysis, UG assisted in data interpretation, and MK helped in reviewing the manuscript. All authors reviewed and approved the final version and agree to be accountable for all aspects of the work.

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Ethical Approval

IRC KAHS: 19th November, 2025. Ref: 2025/085

Consent/Assent

Informed written consent taken from parents.

Data Availability Statement

The data that support the findings are within the article.

Conflicts of Interest

No conflict of Interest

Source of Funding

None

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