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Normative Reference Value for Hand Grip Strength and Sit and Reach Test among School Age Children

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ABSTRACT

Background: Physical fitness indicators such as hand grip strength (HGS) and flexibility, are essential markers of children's growth and functional development. This study aimed to establish culturally relevant normative reference values for hand grip strength (HGS) and the sit-and-reach test (SRT) among school-aged children (6–12 years) in Dhulikhel, Nepal, and to examine the associations of these measures with age, Gender and body mass index (BMI).

Methods: A cross-sectional study was conducted among 359 (52.4% male, 47.6% female) typically developing school children aged 6 to 12 years in Dhulikhel. A TKK (Takei Hand Grip Dynamometer Model T.K.K. 5401) dynamometer was used to measure handgrip strength, and a specially constructed box was used for the sit-and-reach test. Data were analyzed using descriptive statistics with the Statistical Package for Social Sciences, version 26.

Results: Hand grip strength differed significantly by age and sex, with males demonstrating higher mean right (12.11 kg) and left (11.33 kg) handgrip strength than females. Age-stratified analysis revealed a progressive increase in handgrip strength with age in both hands ($p < 0.01$). Likewise, flexibility showed no significant gender ($p = 0.61$) or age-related differences ($p = 0.10$). BMI correlated moderately with handgrip strength (right: $r = 0.485$; left: $r = 0.494$) but weakly with flexibility (Spearman's rho = 0.037).

Conclusions: This study provides culturally relevant normative reference values for handgrip strength and flexibility in school-aged children and its association with age, gender and BMI.

Keywords: Dynamometer; flexibility; handgrip; normative values; strength.

INTRODUCTION

Flexibility is the capacity to move joints and muscles through their entire range of motion, whereas strength is the maximum power that a muscle can produce during a particular action or effort. [1] Handgrip strength (HGS) is the amount of static force that the hand can generate and is a measure used to predict upper extremity strength. It is crucial for the assessment of hand function. [2]

Flexibility and strength reduce the risk of musculoskeletal injuries and osteoporosis later in life. [3] Strength and flexibility training improves mental health and academic performance in children, while inadequate flexibility leads to a higher prevalence of injuries. [4-6]

Previous studies demonstrate significant cross-cultural variations across racial, ethnic, and regional influences on physical development. However, research on physical fitness parameters remains limited, necessitating population-specific normative reference values. [7-13] Therefore, this study aimed to determine the normative reference values for HGS and sit-and-reach tests among school-aged children.

METHODS

Ethical approval was obtained from the Institutional Review Committee (IRC) of the Kathmandu University School of Medical Sciences. Written informed consent was obtained from the parents of all participants before the data collection. In addition, verbal assent was obtained from each child participant after the study

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procedures were explained in simple, age-appropriate language. The researcher ensured that each child understood that participation was voluntary and that they could withdraw at any time without consequence.

The inclusion criteria for this study were school-aged children between 6 and 12 years of age, who were willing to participate and had parental consent. The exclusion criteria included children with known developmental disabilities, pre-diagnosed chronic diseases, critical illness, and signs of excess exertion during the test.

The data collection was carried out from October 2023 to March 2024. The study was conducted in five selected schools. Simple random sampling using the envelope method was used to select the schools. A total of 359 participants were recruited using stratified random sampling based on age and gender to ensure that the sample was representative of the school-aged population.

Prior to data collection, the schools were visited to distribute consent forms to students, which were signed by parents and returned on the day of data collection. The contact details of the investigator were included in the consent form in case the parents had any questions or needed clarification. Data collection was conducted by the investigator in a hall at each school, where two stations were set up: one for measuring handgrip strength and another for the sit-and-reach test.

Handgrip Strength Measurement: Handgrip strength was measured using a TKK Handgrip Dynamometer, a reliable and validated tool with an Interclass Correlation Coefficient (ICC) of 0.89 - 0.96 and validity of 0.99.[14] The participants were instructed to stand in a neutral position with their arms at their sides and to squeeze the dynamometer with maximum force for 3-5 seconds. Each hand was tested thrice, and the highest score for each hand was recorded. [15]

Flexibility was assessed using a sit-and-reach box with a scale. The participants were asked to remove their shoes and sit with their legs extended and feet flat against the box. They were allowed three practice trials, after which the fourth trial was recorded. The maximum reach distance (in centimeters) was measured to the nearest centimeter. This test showed excellent reliability (ICC = 0.92) [16] and moderate validity (0.46 - 0.67). [17]

RESULTS

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics were used to summarize the demographic information and test results. Correlation analysis was used to examine the associations between handgrip strength and flexibility with demographic variables such as age, sex, height, and weight. The significance level was set at $P < 0.05$.

A total of 359 students participated in the study, with a male-to-female ratio of 188:171. The average mean age was 9.92 ± 1.8 years old. The mean right HGS was 12.11 kg (minimum 3.4 kg and maximum 35.1 kg). The mean left HGS was 11.33 kg (minimum 5.0 and maximum 37.8), and for the sit-and-reach test, the mean was 26.6 cm (minimum 7.0 and maximum 39.5). (Table 1)

The results showed no significant difference in flexibility, as measured by the sit-and-reach test ($p = 0.10$) (Fig1). However, there were significant differences in hand grip strength between the right ($p = 0.00$) and left ($p = 0.00$) hands. (Fig 2 and Fig 3).

There was no significant difference between the genders in the Sit & Reach test ($p = 0.61$). However, there were highly significant differences in hand grip strength for both the right ($p = 0.00$) and left ($p = 0.00$) hands.

The results indicated a weak positive association between BMI and the Sit & Reach test (Spearman's rho = 0.037), which was not statistically significant ($p > 0.05$). In contrast, a moderate positive correlation was observed between BMI and Hand Grip Strength in both the right ($r = 0.485$) and left ($r = 0.494$) hands, which was statistically significant ($p < 0.01$). (Table 3)

Table 1: Characteristics of study participants

Variables		Mean Std. Deviation (SD)
AGE		9.92 (±1.802)
Hand Grip	Right (kg)	12.1(±4.5)
	Left(kg)	11.33(±4.3)
SIT AND REACH TEST (cm)		26.6 (±5.5)
Gender		*N (%)*
Male		188 (52.4)
Female		171 (47.6)

Table 2: Mean and S.D of handgrip strength and sit and reach test.

Variables	Age	Gender (N)	Right/Left	Mean	SD
Handgrip strength	6-9	Male (57)	Right	8.8	2.37
			Left	8.42	2.53
		Female (63)	Right	8.06	2.46
			Left	7.54	2.07
	10-12	Male (120)	Right	15	4.27
			Left	12.41	4.71
		Female (96)	Right	13.27	3.69
			Left	12.11	3.49

Table 3: Association between BMI with handgrip strength and sit and reach test

	Test		P-value	
Gender	Sit & Reach test	Mann-Whitney Test	0.61	
	Hand grip strength (R)		0.00	
	Hand grip strength (L)		0.00	
			P-value	Spearman's rho
BMI	Sit & Reach test	Spearman's rho (r)	0.488	0.037
	Hand grip strength (R)		0.000*	0.485*
	Hand grip strength (L)		0.000*	0.494*

*Statistically significant

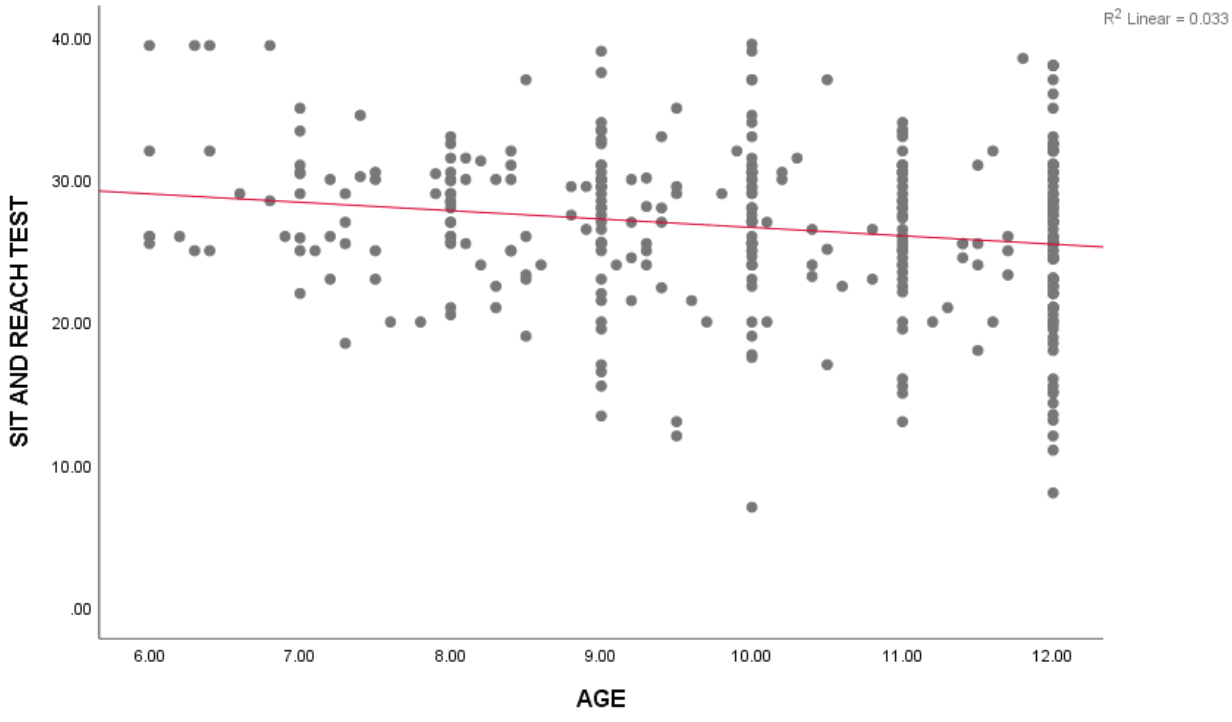

Fig 1: Association between age and sit and reach test

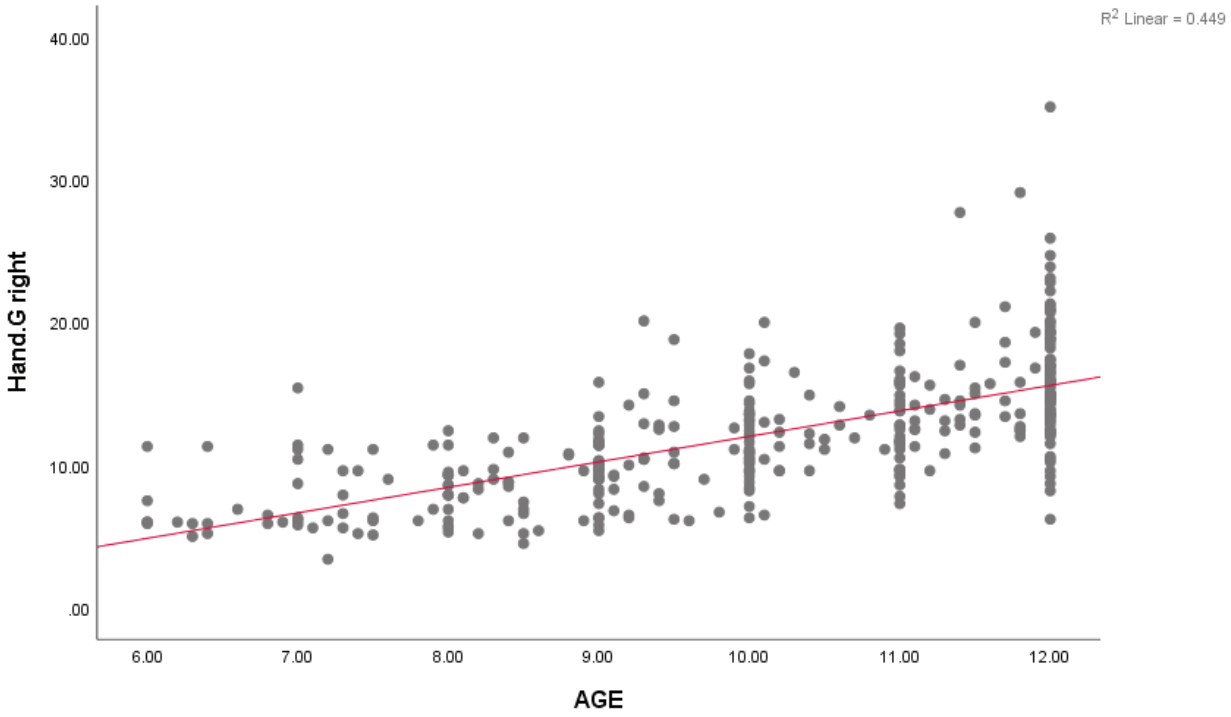

Fig 2: Association between age and handgrip strength (Right)

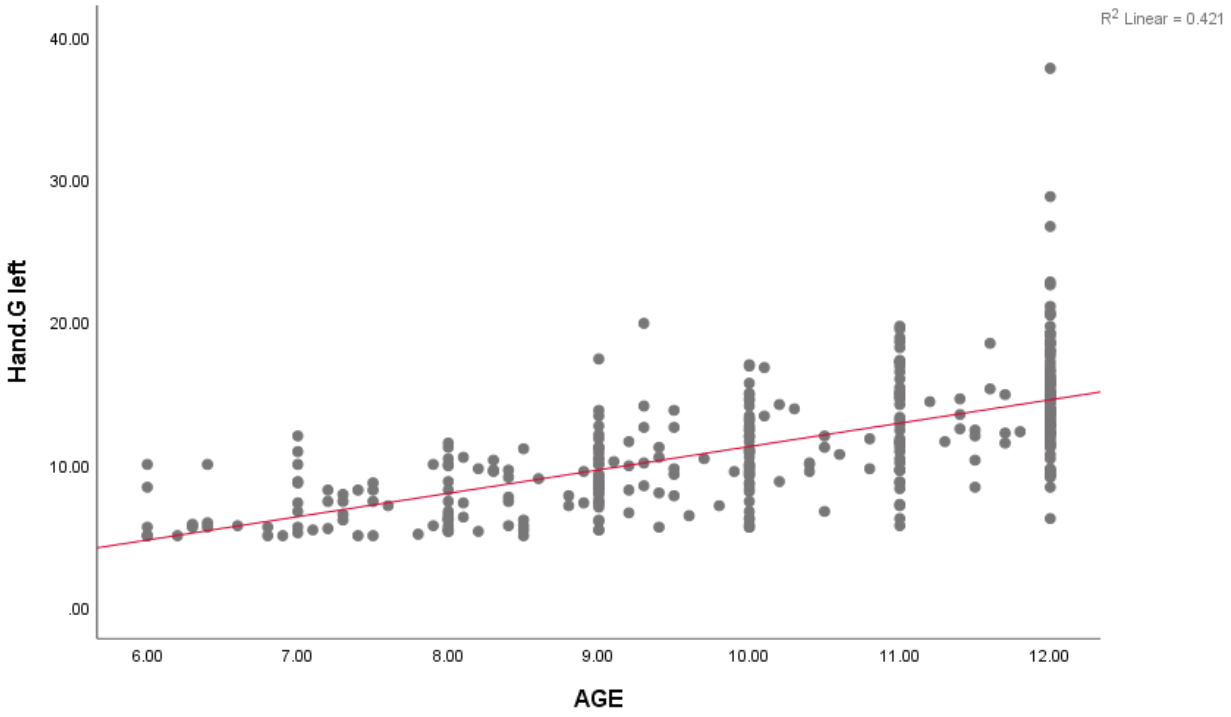

Fig 3: Association between age and handgrip strength (left)

DISCUSSION

This study presents valuable reference data on handgrip strength and flexibility in school-aged children from Dhulikhel, Nepal. The associations between strength and flexibility measures and demographic and anthropometric variables within different age categories identified some important relationships. The result shows that handgrip strength significantly increases with age, particularly in males, which aligns with the typical developmental pattern of muscle strength seen globally.[18,19,20]The observed higher handgrip strength in males at all ages is consistent with other international studies, where gender disparities in strength are widely established.[21,22]Flexibility, as assessed by the sit-and-reach test, shows a steady decline with age, with no significant gender differences, indicating that gender does not affect flexibility and suggesting that age is the primary factor influencing flexibility. Increased muscle stiffness, changes in tendon properties and limb length growth could explain the decline in flexibility with increasing age. There are conflicting findings in the literature on hand grip strength and flexibility, depending on variations in the age range of participants, measurement protocols, and testing devices used. For instance, grip strength increases with age during childhood and adolescence due to changes in muscle mass. [23]. However, some studies have reported different normative values depending on different dynamometer used. [24] Similarly, flexibility assessments, such as the sit-and-reach test, gives inconsistent results based on differences in participant age, limb length proportions, warm-up status, and test administration techniques. [25]

Some studies report body mass as the strongest correlate with muscle strength in children, [26] while others demonstrate, that height showed the strongest relationship and was the most significant predictor of strength, [27] reinforcing the notion that strength development in children is highly dependent on physical growth and maturation. Moreover, the study's findings emphasize the significance of region-specific data, as diet, physical activity, and cultural traditions all influence physical fitness levels. [28,29]

Future research should incorporate broader geographical samples and consider factors such as nutrition, habitual physical activity, and genetic predisposition to better understand the determinants of physical fitness in Nepalese children.

CONCLUSIONS

This study developed local reference data for handgrip strength and flexibility among school-aged children. The results indicate a clear age-related increase in handgrip strength, with males showing superior strength compared to females. Conversely, flexibility declines with age, with no notable gender differences suggesting that age, rather than sex, plays a more influential role in joint flexibility during childhood. These normative values provide a valuable reference for physical fitness assessment in clinical, educational, and community settings.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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