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Normative Reference Values for Hand Grip Strength and Pinch Strength among Rural Indian Adolescents

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ABSTRACT:

Background: Hand grip strength and pinch strength are acknowledged as simple and accurate indicators of upper extremity function, physical development and nutritional status in children and adolescents. Normative data can be used as criteria by clinicians, paediatricians, physiotherapists, and sports scientists to evaluate individual performance, growth related changes and develop focused treatments to improve functional and muscular health. However, there is paucity of literature on population-specific reference data for rural Indian adolescents.

Objective: To establish age and gender specific normative reference values for hand grip and pinch strength among rural Indian adolescents aged 12-18 years.

Methods: A cross-sectional study was conducted in schools of rural areas of Palghar district after getting ethical clearance from the institutional ethics committee. 554 healthy adolescents (aged 12-18years) were recruited in the study according to the inclusion and exclusion criteria. All the participants were then assessed for hand grip strength using Jamar Dynamometer and Pinch strength using Jamar Pinch Gauge following the standardized position recommended by American Society of Hand Therapists (ASHT). Descriptive statistics were calculated to generate age and gender specific normative values.

Results: Hand grip and pinch strength demonstrated a progressive increase with age in both males and females. Males showed higher values compared to females across all age groups. Age and gender specific normative reference values for grip and pinch strength were established in adolescent rural population.

Conclusion: This study provides population specific normative reference values for hand grip and pinch strength in rural Indian adolescents. Strength values were significantly influenced by age and gender. These values may assist clinicians, researchers, physiotherapists in screening, planning rehabilitation and monitor growth in rural population.

Keywords: Adolescents, Hand Grip Strength, Pinch Strength, Dynamometer

INTRODUCTION:

Hand grip strength (HGS) and pinch strength are widely acknowledged as simple and accurate measures of upper-limb muscle function and general physical health [(1)]. HGS has been shown to be a reliable indicator of children's and adolescents' nutritional status and skeletal muscle function [(2)]. Because HGS measurement is simple, reliable, and affordable, it is a crucial part of clinical and field-based assessments of physical health. Numerous studies have shown that grip strength is highly correlated with bone mineral

density, total body muscle mass, and even adult long-term mortality and morbidity [3,4]. Hand grip and pinch strength have been used as helpful markers of functional development, growth, and maturation in children and adolescents [5]. Adolescence is a critical time of transition characterized by fast physical development, hormonal shifts, and neuromuscular maturation. The combined effects of diet, exercise, and puberty cause a significant increase in muscle growth and strength during this time [6]. Therefore, to understand normal developmental trajectories and to identify individuals who are exhibiting inadequate or delayed physical growth early on, it is imperative to establish normative, age- and sex-specific reference values for grip and pinch strength [7]. This normative data can be used as criteria by clinicians, paediatricians, physiotherapists, and sports scientists to evaluate individual performance and develop focused treatments to improve functional and muscular health.

The literature offers normative data for grip and pinch strength in several urban and Western populations [8,9]. However, these values are significantly influenced by population-specific factors like socioeconomic background, physical activity, nutritional status, lifestyle, and ethnicity [10]. Consequently, extrapolating urban or global reference values to rural populations could lead to inaccurate or misleading assessments. Most of the studies that are currently available focus on urban or mixed populations, frequently ignoring people who are solely from rural areas, but they have established normative data for children and adolescents in India [11,12]. Adolescents in rural India are known to have different socioeconomic statuses, levels of physical activity, dietary habits, and access to healthcare than their urban counterparts. All these factors have a significant impact on how the body and muscles develop [13].

Muscle strength is significantly influenced by nutritional status. Numerous Indian studies have found that adolescents in rural areas are more likely than those in urban areas to suffer from stunting, undernutrition, and micronutrient deficiencies [14,15]. Skeletal muscle mass, which determines pinch and grip strength, is directly influenced by these factors. Furthermore, anthropometric traits like height, weight, and body mass index (BMI) have a strong association with hand grip strength [16]. Therefore, in addition to their chronological age and sex, normative reference data that considers the unique anthropometric and environmental characteristics of rural adolescents must be developed.

Lack of such region-specific reference standards impedes population-level screening, accurate clinical evaluation, and early detection of nutritional deficiencies or developmental delays. Grip and pinch strength testing may be a useful, affordable functional marker for rehabilitation monitoring, school health assessments, and rural health programs. Establishing normative reference values will help health care providers better interpret data, identify individuals who do not meet expected functional levels, and develop regionally appropriate nutrition and health interventions [17].

This study aims to establish age- and sex-specific normative reference values for hand grip and pinch strength among rural Indian adolescents to address a significant gap in the literature and offer a foundation for precise evaluation of growth, nutritional health, and physical performance in this vulnerable population.

MATERIALS AND METHODS

The study was conducted in schools of rural areas of Palghar district after getting ethical clearance from the institutional ethics committee. 554 participants were recruited in the study according to the inclusion and exclusion criteria. The inclusion criteria were as follows: School going adolescents aged 11-18 years, residing in rural areas, participants with normal range of motion of joints of upper limb, adolescents unable to understand and follow instructions, participants whose parents/guardians provided written informed

assent. Exclusion criteria included: adolescents with current musculoskeletal, neurological, or systemic illness affecting upper limb function, adolescents with pain, swelling in the upper limb. All the participants were then assessed for hand grip strength (using Jamar Dynamometer) and Pinch strength (using Jamar Pinch Gauge).

STUDY PROCEDURE:

Measuring hand grip strength using Jamar hand dynamometer. [18]

To assess hand grip strength, a Jamar hand dynamometer was used as recommended by the American Society of Hand Therapists (ASHT). The American Society of hand therapists standardized arm position for hand strength testing was utilized. Three trials were given to each subject. The mean score among three trials was recorded for data calculations.

Measuring pinch strength using Jamar Pinch Gauge. [18]

To assess pinch strength, a Jamar Pinch Gauge was used as recommended by the American Society of Hand Therapists (ASHT). The American Society of hand therapists standardized arm position for pinch strength testing was utilized. Three trials were given to each subject. The mean score among three trials was recorded for data calculations.

STATISTICAL ANALYSIS:

Data for statistical analysis was entered using MS-excel version 2205. Statistical analysis was performed using Graph Pad Prism (version 9.4.0) software.

RESULT:

I. Normative Data Analysis for Grip and Pinch Strength

Descriptive statistics were calculated to establish normative data for grip and pinch strength in the study population (n = 554). These measures provide insight into hand function capacity across the adolescent sample.

Parameter	N	Mean (kg)	SD	Min	25th	Median	Max
Grip Strength	554	18.32	6.99	2.00	14.00	18.00	44.00
Pinch Strength	554	3.88	1.78	0.50	2.50	3.50	13.50

II. Gender-wise Normative Values

Gender	n	Grip Strength (Mean ± SD kg)	Pinch Strength (Mean ± SD kg)
Female	298	16.72 ± 5.77	3.39 ± 1.47
Male	253	20.27 ± 7.81	4.47 ± 1.94
Total	554	18.32 ± 6.99	3.88 ± 1.78

The grip strength was found to be 21% greater in males than in females and pinch strength was found to be 25% greater than that of females. This depicts known gender-based variations in upper-limb musculature and hand anthropometrics.

Distributional Characteristics

With a near-normal distribution of grip strength (skewness = 0.68; kurtosis = 0.54), the cohort's variability was found to be moderate.

A greater percentage of participants had lower pinch values, and a smaller number of individuals had higher strength, according to the positively skewed pinch strength data (skewness = 1.12).
In accordance with growth-related neuromuscular development, both measures displayed increasing central tendency values with age, height, and body mass.

III. Age-Wise Normative Data for Grip and Pinch Strength

Descriptive statistics were stratified by age to assess developmental trends across adolescence. Both grip and pinch strength increased steadily with age, reflecting neuromuscular, physical growth and neural sharpening.

Age (years)	n	Grip Mean	Grip SD	Grip Median	Grip Max	Pinch Mean	Pinch SD	Pinch Median	Pinch Max
11	5	18.6	5.73	16.0	28.0	4.00	0.71	3.5	5.0
12	118	15.1	4.62	14.5	27.0	3.14	1.30	3.0	8.5
13	124	17.5	6.76	18.0	40.0	3.83	2.03	3.5	13.5
14	137	17.4	6.27	18.0	44.0	3.70	1.54	3.5	10.0
15	87	19.9	7.43	20.0	42.0	4.06	1.69	3.5	10.0
16	68	23.7	7.66	22.0	44.0	5.02	1.99	5.0	12.5
17	15	24.9	6.47	26.0	38.0	5.30	1.41	5.5	7.5

The mean grip strength increased by 65% from 15.1 kg at age 12 to 24.9 kg at age 17. In the same way, mean pinch strength increased by approximately 70%, from 3.1 kg to 5.3 kg. Between the ages of 13 and 16, variability increased in accordance with physiological variations in muscle growth and pubertal onset. The significance of age-specific reference values in the interpretation of hand function data is highlighted by these findings.

DISCUSSION:

The study aimed to develop the age and gender specific normative reference values for hand grip strength and pinch strength among rural adolescent population aged. The data particularly in the rural population is not established and thus study aimed to bridge this research gap. The results of the study indicated a progressive increase in hand grip and pinch strength with increasing age. This reflected the normal musculoskeletal and neuromuscular growth and maturation. [19-21]
Similar trends in hand and grip strength were seen in previous study by Mathiowetz et al. And Massy-Westropp et al. as well attributing to the increase in muscle mass, neuromuscular coordination, hormonal changes seen as age progresses [5,22]. This gradual rise in strength indicates adolescence as a critical period for the development of musculoskeletal system. These findings are like those seen in international and urban Indian population.
Gender variations in both grip and pinch strength were evident from the study. Boys demonstrated a significant increase in values compared to girls. This difference can be attributed to the sex-specific hormonal changes during adolescence, specifically the influence of testosterone hormone on development of musculoskeletal system as described by Beunen and Malina. [23] Previous studies by Shetty et al. And Nara et al., have also reported similar gender differences emphasizing the need to have specific normative values for boys and girls separately for accurate interpretation in research and clinical usage. [19,24]
When the present data is compared to data from existing literature on western and Indian urban population,

it is observed that the values are lower for both grip and pinch strength. Studies by Massy-Westropp et al. And Dodds et al. reported higher strength values among adolescents from urban and developed settings [5,7]. In Indian population, Shetty et al. And Rajendiran et al. Documented higher values in urban population as compared to rural. [1,25] Numerous factors like nutritional status, access to sports and physical activity, infrastructure, availability of resources may have contributed to this variation. If existing reference values (western and urban Indian adolescents) are applied to rural population, it may lead to misjudgement of functional deficits of this population. This further highlights the importance of having separate values for rural Indian adolescent population.

Pinch strength and hand grip strength (HGS) are commonly acknowledged as simple and dependable measures of upper-limb muscle function and general physical health. HGS measurement is an essential component of clinical and field-based evaluations of physical health because it is easy, dependable, and cost-effective. In order to fully understand normal developmental trajectories and to identify individuals exhibiting inadequate or delayed physical growth early on, it is imperative to establish normative, age- and sex-specific reference values for grip and pinch strength. Physiotherapists, sports scientists, paediatricians, and clinicians may use this normative data as criteria to evaluate individual performance and develop focused interventions to improve muscle and functional health in this population. This can assist in identification of individuals who may be at risk of under nutrition, delayed physical development, etc. These may also be useful for monitoring the effect of nutritional and physical activity interventions done on the population.

LIMITATIONS:

Despite its strengths, the study has several limitations as well. The study has not taken into consideration the physical activity levels of this population which could have provided more insight into the observed variations in values obtained. Future longitudinal studies including nutritional status, activity levels, maturation status could be incorporated to get a better understanding of the muscular strength development determinants.

CONCLUSION:

The study has established normative age and gender specific values for grip and pinch strength in adolescent rural population. These findings aim to address a significant literature gap and provide clinically relevant data that can enhance assessment, screening and intervention strategies aimed at improving adolescent health in rural settings.

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