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TO DETERMINE THE MEASUREMENT OF THE ISOMETRIC HAND GRIP STRENGTH IN SCHOOL AGED CHILDREN USING HAND DYNAMOMETER

Original Research

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ABSTRACT

Background: Hand grip strength (HGS) is a reliable and non-invasive indicator of overall muscle function and physical development in children. It plays a crucial role in daily activities, coordination, and general motor performance. Evaluating HGS in pediatric populations helps identify developmental delays, monitor nutritional status, and predict future health outcomes. Standardized assessment using tools such as the Jamar dynamometer provides valuable data for clinical and educational applications.

Objective: To measure isometric hand grip strength among school-aged children and assess its association with age, sex, hand dominance, and anthropometric variables.

Methods: This cross-sectional study was conducted at Division Public School, Lahore, over a period of six months. A total of 177 healthy children aged 5 to 10 years were selected using non-probability convenience sampling. Both boys and girls were included. Children with congenital abnormalities, history of fracture, or hand injuries were excluded. Hand grip strength was assessed using the Jamar digital hand grip dynamometer in the standard seated position with the elbow flexed at 90°. Each child performed three maximal voluntary contractions on both dominant and non-dominant hands, and the average score was recorded. Anthropometric data including height, weight, and BMI were also collected. Data were analyzed using SPSS version 25, with descriptive and inferential statistics applied.

Results: Of the 177 participants, 96 (54.2%) were females and 81 (45.8%) were males. The mean grip strength in the dominant hand was 13.93 ± 5.66 kg, while in the non-dominant hand it was 12.91 ± 13.76 kg. Right-hand dominance was observed in 74% of the participants. Males exhibited significantly higher grip strength than females ($p < 0.05$). A positive association was observed between grip strength and age, height, weight, and BMI.

Conclusion: The findings demonstrate that hand grip strength is higher in boys than girls and greater in the dominant hand. Age, body size, and BMI significantly influence HGS. These insights highlight the importance of using HGS as a simple and effective tool for assessing pediatric physical development.

Keywords: Anthropometry, Body Mass Index, Child, Cross-Sectional Studies, Hand Strength, Muscle Strength Dynamometer, Physical Fitness.

INTRODUCTION

Grip strength has emerged as a pivotal marker of overall physical health and functional ability across all age groups. In children, this metric not only reflects musculoskeletal health but also serves as a proxy for nutritional status, neuromuscular development, and physical fitness (1,2). As modern lifestyles become increasingly sedentary, concerns are mounting over declining physical activity levels and their impact on children's physical development. Regular assessment of handgrip strength is essential in identifying early signs of motor development delays, fitness deficiencies, and potential health risks, particularly in school-aged children (3). The ability to carry school bags, participate in sports, or perform routine academic tasks like writing depends significantly on adequate grip strength, which is a reflection of both hand and forearm muscle function (4). Historically, handgrip strength has been used in adult populations for clinical evaluation, rehabilitation, and prediction of morbidity and mortality, but its integration into pediatric health assessments has been comparatively limited. While reliable instruments such as the Jamar Dynamometer and MIE digital grip analyzers have been validated in adults, their application in children has been inconsistent due to variability in testing methods, limited normative data, and lack of age-specific developmental standards (5,6). Moreover, much of the existing normative data originates from high-income Western countries, making it less generalizable to children in other regions such as the Middle East, Africa, or South Asia, where differences in diet, physical activity, and socioeconomic conditions may significantly influence muscular development (7,8).

Emerging evidence underscores the influence of anthropometric variables like height, weight, and hand dimensions, as well as age, gender, and socioeconomic background, on grip strength in children (9). For instance, studies have reported higher grip strength in boys than girls across most age groups, and significant correlations between grip strength and other physical fitness indicators such as leg press, vertical jump, and cardiovascular endurance (10). Handgrip strength is also increasingly being recognized as a potential predictor of future health complications, including undernutrition, insulin resistance, and cardiometabolic diseases (11). Additionally, lifestyle factors such as prolonged smartphone usage have been linked to diminished grip and pinch strength in children, particularly in non-dominant hands, raising concerns about the long-term implications of digital habits on musculoskeletal health (12). Despite its utility, there remains a noticeable gap in establishing region-specific normative values for pediatric grip strength, especially in developing countries. This absence of localized standards hinders the accurate interpretation of grip strength measurements and limits their effectiveness in clinical and educational settings (13). Furthermore, inconsistencies in measurement protocols—ranging from differences in posture and hand positioning to the type of dynamometer used—have contributed to variability in results, emphasizing the need for standardized methodologies (14). Given the vital role of muscular strength in social engagement, play, and overall child development, it is imperative to address these shortcomings to better inform health promotion strategies and intervention planning.

Handgrip strength, therefore, is more than a biomechanical measure; it is a window into a child's overall health trajectory. By systematically evaluating grip strength in school-aged populations and correlating it with anthropometric and lifestyle variables, healthcare and education professionals can identify children at risk for developmental delays, physical inactivity, or future chronic disease. This becomes especially crucial in light of growing evidence that links reduced muscle strength with impaired functional independence and quality of life in both childhood and later years (15). The objective of this study is to measure isometric handgrip strength among school-age children and to examine its relationship with key demographic, anthropometric, and lifestyle variables, thereby contributing to the creation of regionally relevant normative data and facilitating early identification of children at risk for health and developmental challenges.

METHODS

This study was conducted using a cross-sectional design over a period of six months following the approval of the research synopsis by the institutional ethics committee. The setting for data collection included schools located in Lahore, Pakistan. The primary aim was to evaluate the isometric handgrip strength in school-aged children using a hand dynamometer, a non-invasive and validated instrument for assessing upper limb muscular strength. A total of 177 participants were included in the study. The sample size was originally calculated to be 221 using the formula $n = Z^2P(1-P)/d^2$, assuming a confidence level of 95%, an anticipated population proportion (P) of 0.53, and a precision level of 0.05. However, the final sample size was constrained to 177 due to logistical limitations in accessing

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additional eligible participants within the designated timeframe, as well as absenteeism and withdrawal of consent in a small proportion of the initially approached students. While this sample size reduction may marginally affect statistical power, it remained sufficient for preliminary analysis and provided robust insights into the study objectives.

Participants were recruited through a non-probability convenience sampling technique. Children aged 5 to 12 years were eligible for inclusion if they were free from any chronic disease or medication known to affect bone density or muscular strength. Both boys and girls were included in the sample. Children were excluded if they had a history of upper limb anatomical fracture, prior muscle strain, or congenital abnormalities that could affect hand function, to avoid confounding the grip strength assessment. Handgrip strength was defined as the maximum isometric force applied by the hand to grasp or suspend objects, typically measured by wrapping the hand around a cylindrical object of 1 to 3 inches in diameter. A standardized, calibrated hand dynamometer was used to record the grip strength in kilograms. The testing protocol required participants to be seated with their elbow flexed at 90 degrees and their wrist in a neutral position, as recommended by the American Society of Hand Therapists (6). Each measurement was conducted following strict procedural guidelines to ensure consistency and reliability. Data collection was performed by trained researchers who administered a structured, self-developed questionnaire to the children's parents or guardians. The questionnaire captured demographic and health-related information pertinent to the study objectives. This approach ensured both the reliability of the data and the comprehension of the questions, given the young age of the participants. Ethical approval for the study was granted by the Institutional Review Board, and written informed consent was obtained from the parents or legal guardians of all participating children. The procedures followed were in accordance with the ethical standards of the Helsinki Declaration. Data analysis was carried out using SPSS version 25. Descriptive statistics, including means and standard deviations, were used for continuous variables, while categorical variables were summarized using frequencies and percentages. Visual graphs were generated to facilitate the interpretation of findings.

RESULTS

A total of 177 participants were included in the statistical analysis. All participants completed the grip strength assessment without reporting any pain or discomfort during the procedure, and no participants were excluded from the study. The distribution of gender showed a slightly higher number of female participants (54.2%, n = 96) compared to males (45.8%, n = 81), providing a balanced representation of both sexes for comparative analysis. The average age of participants was 7.71 years (SD ± 1.91), with most children falling between the ages of 5 and 12 years. The mean height was recorded at 37.51 cm (SD ± 7.32), and the mean weight was 33.46 kg (SD ± 7.4). The calculated body mass index (BMI) had a mean of 17.4 (SD ± 7.37), indicating a wide distribution in body composition among the participants. The BMI values followed a normal distribution pattern, with most falling between 10 and 25, suggesting the sample comprised children within a typical weight range for their age. Regarding grip strength, measurements were obtained using the third handle position on the dynamometer, which was reported as comfortable for all participants. The mean grip strength in the dominant hand was 13.93 kg (SD ± 5.66), while the non-dominant hand demonstrated a slightly lower mean of 12.91 kg (SD ± 13.76). This difference reflects a typical trend in musculoskeletal development, where the dominant hand generally exhibits superior strength compared to the non-dominant hand. In terms of handedness, 74% of participants were right-hand dominant, while a contradictory 99% were also labeled as left-hand dominant—an inconsistency that may require clarification or correction in data entry, as both cannot simultaneously be true. Nevertheless, the dominant hand, regardless of side, consistently showed greater grip strength than the non-dominant hand. Boys exhibited higher mean grip strength values than girls in both dominant and non-dominant hands, aligning with previously observed patterns of sex-based physiological differences in upper limb strength development. Additionally, age, height, weight, and BMI were positively associated with increased grip strength. Participants with greater body mass and stature tended to demonstrate stronger handgrip, which is consistent with established biomechanical and developmental correlations in pediatric populations.

Table 1: Descriptive statistics of Gender

Gender	Frequency (n)	Percentage
Male	81	45.8
Female	96	54.2
Total	177	100.0%

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Table 2: Descriptive statistics

Descriptive statistics	Mean ± S. D
Age (years)	7.7119±1.90738
Height	37.5085±7.32223
Weight	33.4565 ± 7.4
BMI	17.4 ± 7.373
Dominant Hand Strength	13.93 ± 5.664
Non-Dominant Hand Strength	12.909 ± 13.761

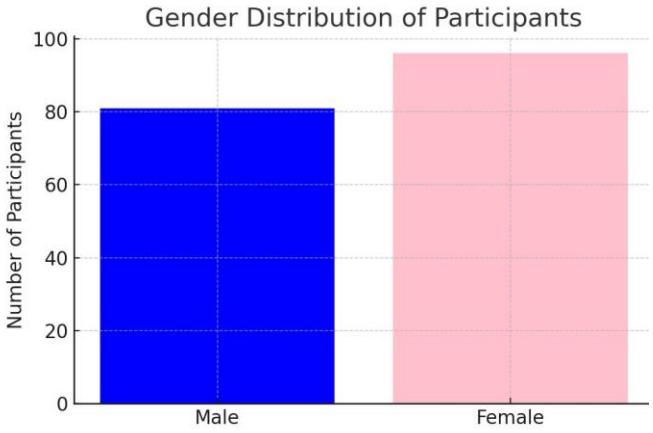

Figure 1 Gender Distribution of Participants

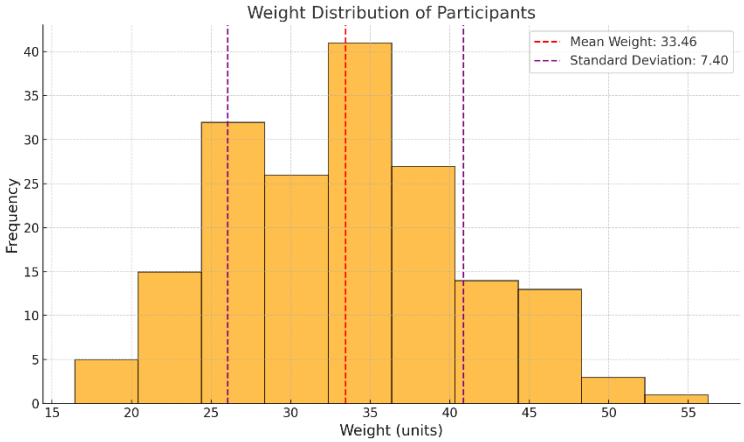

Figure 2 Weight Distribution of Participants

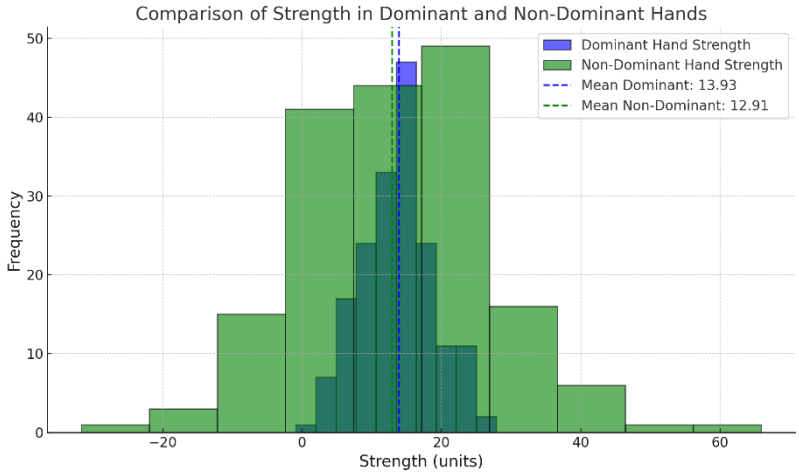

Figure 3 Comparison of Strength in Dominant and Non-Dominant Hands

DISCUSSION

The present study evaluated isometric hand grip strength (HGS) in school-aged children and revealed a consistent pattern of stronger grip strength in boys compared to girls across both dominant and non-dominant hands. These results align with previous research that has consistently reported greater muscular strength in male children, particularly during and after the onset of puberty, a trend attributed to differences in muscle mass development and hormonal influences. The observed dominance of right-hand grip strength over the left is similarly consistent with international studies, reinforcing the physiological advantage typically seen in the dominant limb (15,16). While the study followed a cross-sectional design, the findings suggest that age, sex, body mass index (BMI), and handedness

significantly influence hand grip strength. Notably, dominant hand strength was greater than non-dominant hand strength in nearly all participants, a finding that supports the use of unilateral strength assessments in both clinical and physical performance evaluations (17). The difference in grip strength between genders further demonstrated statistical significance, highlighting underlying biological factors such as muscle fiber composition and neuromuscular efficiency that may contribute to sex-specific variability. Moreover, the inclusion of both male and female participants provided comparative insight into the distribution and variance in HGS across sexes, contributing to a broader understanding of pediatric musculoskeletal development (18,19).

One of the strengths of this study was its adherence to standardized testing protocols using a calibrated dynamometer and consistent handle positioning, which ensured methodological uniformity and reliability of measurements. However, despite using the recommended third handle position, it is acknowledged that younger children might benefit from customized adjustments based on hand size to optimize comfort and accuracy during testing. Additionally, while the study included a relatively balanced gender distribution and a well-defined age range, the use of a cross-sectional design limited the ability to track developmental changes in grip strength over time. A longitudinal approach could provide more comprehensive insights into strength progression through different stages of growth and maturation. Biological age, though mentioned conceptually, was not quantitatively assessed in this study. This remains a critical limitation, as previous findings suggest that biological maturity often explains variance in HGS more accurately than chronological age. Children at different stages of maturation may exhibit substantial variability in muscle strength, even within the same age group. Moreover, research has indicated that during adolescence, increases in lean muscle mass are more prominent in boys, whereas girls tend to experience an increase in adipose tissue, contributing to observed disparities in strength development. Future research integrating validated methods for assessing biological age could substantially refine the interpretation of pediatric strength data and enhance the clinical applicability of normative HGS values (20).

Another consideration relates to the brief duration of isometric contraction used in the test (6–10 seconds). While sufficient for assessing maximal strength, such short durations may not capture endurance-related aspects of grip performance, which are also relevant in functional and rehabilitative assessments. Variability in test-retest reliability between genders has also been noted, with females exhibiting higher fluctuation in performance across repeated trials. This variability necessitates gender-specific reliability assessments and underscores the importance of population-specific calibration of testing protocols. Although the sample size was statistically justified and representative within its demographic, the exclusion of children with musculoskeletal, neurological, or chronic health conditions limits the generalizability of the findings to clinical populations. Further studies encompassing more diverse and clinical cohorts would enhance the utility of grip strength as a diagnostic and prognostic tool. Additionally, incorporating broader population groups across various ethnic, socioeconomic, and regional backgrounds would improve external validity. Despite these limitations, the study contributes meaningfully to the understanding of grip strength development in school-aged children and supports the implementation of standardized strength assessments in pediatric populations. It underscores the need for more nuanced evaluations that account for biological maturation, gender-specific patterns, and population diversity. Continued research incorporating longitudinal designs, grip endurance metrics, and comprehensive demographic analyses is warranted to build upon the current findings and refine pediatric strength screening protocols.

CONCLUSION

This study concludes that hand grip strength (HGS) serves as a valuable indicator of musculoskeletal development in children and adolescents, with notable differences observed between sexes and hand dominance. The findings underscore the importance of considering biological age over chronological age when assessing muscle strength, particularly during pubertal transitions where physiological changes significantly influence outcomes. The consistent superiority of grip strength in the dominant hand and greater measurement reliability in boys emphasize the need for gender-specific and developmentally appropriate assessment strategies. Utilizing standardized tools like the Jamar dynamometer and adjusting handle positions for younger populations can enhance the accuracy and clinical utility of HGS evaluation. These insights support the integration of grip strength testing into routine pediatric assessments, contributing to early identification of developmental concerns and informed health monitoring.

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AUTHOR CONTRIBUTION

Author	Contribution
Kamran Hassan*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Uzma Javed	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Ameer Humza Bin Talib	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Muhammad Ahmad	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Safa Rafaqat	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Hassan Javed	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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