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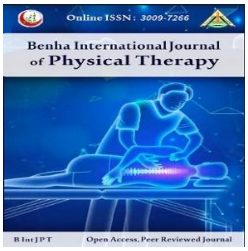

Original research

Impact of BMI and gender on hand grip strength among Egyptians: A cross-sectional study

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Abstract:

Background: Obesity negatively impacts physical performance, while hand grip strength is an indicator of musculoskeletal strength; therefore, obesity may also negatively impact hand grip strength. **Purpose:** The objective of this study was to compare hand grip strength between abnorma and normal-weight adolescents and to assess the impact of sex on grip strength measurements. **Methods:** A cross-sectional study of 200 adolescents (40 male and 160 female) aged 11 to 15 years was performed. Participants were classified as 28 Abnormal weight (≥ 85th percentile BMI) and 172normal weight (<85th percentile BMI). Hand grip strength was evaluated with a handheld dynamometer, and relative grip strength was determined by normalizing absolute strength to body mass index. Statistical analysis was conducted using the Mann-Whitney U test to compare median values between groups, with significance set at $p < 0.05$. **Results:** Abnormal weight males demonstrated significantly higher weight, BMI, and absolute handgrip strength (HGS) strength compared to normal-weight males ($p < 0.001$), but no significant difference in relative strength. Among females, abnormal weight participants had markedly higher weight and BMI ($p < 0.001$), and significantly lower relative handgrip strength (HGS) strength than normal-weight females ($p < 0.001$), with no significant difference in absolute handgrip strength (HGS)". These findings highlight pronounced gender-specific patterns in strength and body composition associated with obesity. **Conclusions:** Increased body weight enhances absolute grip strength in males, while in females its lower strength relative to BMI, highlighting the importance of considering both gender and body composition when assessing muscle strength in adolescents'

Key Words: Adolescents, Body mass index, Handgrip strength (HGS), Obesity, Youth health.

Introduction

Obesity, characterized by an accumulation of excessive body fat, constitutes a significant public health concern in Egypt, with 13.3% of adolescents classified as abnormal weight and 26.5% as overweight, as reported in a study published in the Egyptian Journal of Community Medicine [1]. Lifestyle factors such as excessive energy intake and sedentary behavior are associated with obesity and a heightened prevalence of metabolic disorders. Unhealthy dietary practices, particularly the regular intake of fast food, aggravate this problem and increase the risk of obesity[2]. Socioeconomic status also plays a part. Teenagers are more likely to be overweight, possibly because they have easier access to high-calorie foods and do not move around as much[3].

Studies indicate that hand grip strength (HGS) is correlated with other muscle groups and functional activity performance and serves as a diagnostic tool for sarcopenia, frailty, and mortality risk[4]. Sports scientists monitor athletes' performance and recovery via HGS. It monitors muscular endurance, fatigue, and neuromuscular performance[5]. Previous research has shown that hand grip strength (HGS) improves the social and environmental quality of life in older adults. However, studies specifically addressing the relationship between HGS and weight categories among adolescents are limited, highlighting a significant research gap[6]. Higher hand grip strength was significantly associated with a lower prevalence of moderate to severe problems across all five EQ 5D quality of life questionnaire dimensions in postmenopausal Korean women[7]. HGS is influenced by nutrition, physical activity, and persistent illnesses; individuals require a balanced diet and consistent physical activity to preserve muscle function[8].

The relationships between obesity and hand grip strength (HGS), a measure of total muscular strength and physical function, have been extensively investigated. Obesity may help or negatively affect HGS depending on muscle mass, body composition, and fat distribution. A high BMI increases mechanical stress, promoting muscle strength, particularly in young adults with high lean body mass[9].

BMI and hand grip strength were correlated in both sexes. Teens in Spain reported that overweight people had stronger hand grips[10]. Therefore, there is a need to study the relationship between HGS and obesity in other populations to allow for broader generalization of the results. Obesity reduces mobility, grip strength, functional and strength[11]. Sarcopenic obesity, defined by diminished muscle mass and increased fat, is associated with metabolic dysregulation and increased frailty, thereby increasing the risk of physical disabilities[12]. HGS is increasingly utilized for metabolic disease screening, with obesity associated with increased cardiovascular risk, insulin resistance, and death. Strength training and weight management strategies are advised[13].

Despite extensive research linking obesity and hand grip strength across age groups and regions, limited data exist on Egyptian adolescents, highlighting the need for localized, population-specific investigations.

Methods

This cross-sectional study included 200 adolescents from 15th May Educational Region preparatory and secondary school adolescents from October 1, 2024, to January 1, 2025. All the adolescents were between 11 and 15 years old, all adolescents were screened for any history of musculoskeletal trauma or upper limb surgery that could influence grip strength, and those reporting such conditions were excluded from the study. Left-handed adolescents were excluded from the study.

Sample Size calculation:

The sample size was determined via the technique for calculating a single population percentage, with an assumed obesity prevalence of 13%, a 95% confidence level, and a 5% margin of error.

Participants:

Every student's weight, height, age, and sex were examined. Body mass index was determined and classified by BMI-for-age girls 5 to 19 years (percentiles) and boys 5 to 19 years (percentiles) as abnormal equal to or above the 85th percentile and normal below the 85th percentile.

Ethics approval and consent to participate:

The study was conducted following the ethical standards and received approval from Cairo University's Faculty of Physical Therapy Research Ethical Committee accepted the study protocol on February 9, 2025 (Approval No. P.T. REC/012/005705).

Procedures:

A standard technique was followed to measure body weight accurately on a digital portable weight scale. First, the scale was set on a flat, hard surface to avoid measurement errors. Before use, the device was powered on and calibrated to zero the display. The participants were asked to remove heavy clothing and shoes to reduce their weight. Each person went onto the scale barefoot to properly disperse their weight. They stood still when the scale revealed their final weight. The measurement was captured immediately after it appeared on the digital screen for recordkeeping. For uniformity, the method was repeated, and inconsistencies were noted. The scale was calibrated periodically to preserve accuracy during data gathering. Owing to their portability, digital weight scales are used in many locations. Accurate measurements require reliability and validity testing. The measurement repeatability under identical conditions is called reliability. A digital weighing scale (DWS) study revealed high intra- and interrater reliability, with ICCs ranging from 0.94 to 0.97. This suggests that DWSs measure weight consistently across trials and examiners. DWSs are compared to those of MatScan, a standard limb loading instrument. The two devices agreed well, demonstrating that DWSs can measure weight distribution and limb loading[14].

Body height was measured with a tape measure and chalk. The participants touched their heads, shoulders, buttocks, and heels to a flat wall while barefoot. A flat object was placed on top of the head and gently pressed against the wall, and the highest height obtained was noted. Some chalk was applied to mark this area. After marking the height and moving away from the wall, the researcher used a tape measure to measure the floor-to-mark distance. This method supplies accurate and straightforward height measurements[15].

Body mass index (BMI) has long been used to assess teenage obesity because of its simplicity and convenience. Recent investigations have found that its validity and dependability are limited in this demographic. Research suggests that BMI may misclassify adolescents' weight status on the basis of body fat percentage. BMI assessments can be affected by growth patterns, puberty, and muscle mass, decreasing their accuracy as obesity indicators in teens. BMI, despite its limitations, is widely used in large-scale studies to identify obesity trends[16,17,18,19].

Simple math was used to calculate BMI. Height in meter was squared to obtain the BMI denominator after weight and height were assessed. BMI was calculated by dividing weight by height squared. This result was compared with BMI-Age tables (boys-girls), which were created if they were below the 85th percentile, they are normal weight and if they are equal or above 85th percentile, they are abnormal weight.

Handheld dynamometers are commonly used to measure grip strength. A handheld dynamometer was used to analyze handgrip strength (HGS) strength[20]. Another Archives of Physical Medicine and Rehabilitation paper offered handheld dynamometer limb muscle strength reference values across different age groups[21]. A 2013 cross-sectional study provided normative grip strength values for children and adolescents using a handheld dynamometer, supporting its use in this age group[22]. These findings emphasize the usefulness of handheld dynamometers for muscular strength assessment in clinical and research contexts.

The handheld dynamometer method for evaluating hand grip strength was standardized to ensure accuracy and consistency. The dynamometer was calibrated per the manufacturer's instructions before use. The participants sat in a chair with back support and flat feet to maintain a stable posture. To avoid leverage, the testing arm had a neutral shoulder, 90-degree elbow, forearm supinated and neutral wrist. The dynamometer's handle was adjusted to accommodate the participant's hand, with the base against the palm and fingers around the handle. The participants were then told to squeeze the dynamometer firmly for five seconds without moving their arm or body. Standardized verbal reinforcement ensured maximum effort. The final grip strength test was the average of three trials with 60 seconds rest intervals between trials to avoid tiredness. In clinical and research contexts, this method yielded consistent and reproducible results. Relative hand grip strength was calculated by dividing the measured grip strength by the participant's BMI, given in kg/m^2. This method normalizes grip strength to account for participant body size[23].

Data Analysis

Statistical analysis included both descriptive and inferential methods. Categorical distributions of participants by gender and weight status (normal or abnormal weight) were summarized using a cross table, presenting counts and percentages for each subgroup. Continuous variables—including age, weight, height, body mass index (BMI), average handgrip strength (HGS) strength, and relative handgrip strength (HGS) strength—were compared between normal and abnormal groups within each gender using the Mann-Whitney U test, as preliminary assessment indicated non-normal data distributions. Results are reported as medians and interquartile ranges (IQR). Statistical significance was defined as $p < 0.05$. All analyses and boxplot visualizations were performed using

PASW Statistics 18 (Predictive Analytics Software) software.

Results

Table 1 presents the distribution of participants by gender and weight status. Of the total sample (n = 200), the majority were females with normal weight (n = 144, 72.0%), followed by males with normal weight (n = 28, 14.0%), females with abnormal weight (n = 16, 8.0%), and males with abnormal weight (n = 12, 6.0%). Overall, 86.0% of the sample were classified as having normal weight, while 14.0% were classified as abnormal weight. The proportion of abnormal weight individuals was higher among females (8.0%) than among males (6.0%).

Table 1: gender and weight distribution.

Gender	**Normal n (%)**	**Abnormal n (%)**	**Total n (%)**
Female	144 (72.0%)	16 (8.0%)	160 (80.0%)
Male	28 (14.0%)	12 (6.0%)	40 (20.0%)
Total	172 (86.0%)	28 (14.0%)	200 (100.0%)

n= Number, %= percentage.

Table 2 presents the median and interquartile range (IQR) for age, weight, height, body mass index (BMI), absolute handgrip strength (HGS)", and relative strength in four distinct groups: normal male, abnormal male, normal female, and abnormal female. For each variable, statistical comparison between the normal and abnormal groups within each gender was performed using the Mann-Whitney U test. Significant differences ($p < 0.05$) were observed in body mass index, weight, and absolute handgrip strength (HGS)" among males, as well as in weight, body mass index, and relative strength among females. Among males, abnormal individuals demonstrated significantly higher weight (median: 62.0 vs. 50.0 kg, $p < 0.001$) and BMI (median: 24.23 vs. 19.78 kg/m², $p < 0.001$) compared to their normal counterparts. Absolute handgrip strength (HGS)" was also elevated in abnormal males (median: 29.80 vs. 21.13, $p = 0.002$). No significant differences were found for age, height, or relative strength. Among females, abnormal individuals had markedly higher weight (median: 66.0 vs. 42.5 kg, $p < 0.001$) and BMI (median: 26.61 vs. 17.26 kg/m², $p < 0.001$), and significantly lower relative strength (median: 0.41 vs. 0.70, $p < 0.001$). Age, height, and absolute handgrip strength (HGS)" did not differ significantly between normal and abnormal females.

Table 2: Age, Weight, Height, Body Mass Index, absolute Strength, Relative Strength.

Variable	**Group (n)**	**Median (IQR)**	**Mann-Whitney U**	**p-value**
Age	normal male (28)	14.00 (12.75–14.50)	202.0	0.316
	abnormal male (12)	13.00 (12.79–13.25)		
	normal female (144)	12.91 (12.57–13.12)	1172.0	0.911
	abnormal female (16)	12.85 (12.45–13.44)		
weight	normal male (28)	50.00 (40.00–50.00)	0.0	4.95×10^{-7}
	abnormal male (12)	62.00 (58.60–68.40)		

Variable	Group (n)	Median (IQR)	Mann-Whitney U	p-value
	normal female (144)	42.50 (40.00–45.00)	32.0	1.44×10^{-10}
	abnormal female (16)	66.00 (62.00–70.25)		
height	normal male (28)	158.00 (158.00–159.00)	188.0	0.554
	abnormal male (12)	156.11 (151.95–160.70)		
	normal female (144)	155.00 (152.50–159.25)	1268.0	0.510
	abnormal female (16)	154.80 (152.42–158.57)		
body mass index	normal male (28)	19.78 (16.02–19.78)	0.0	4.95×10^{-7}
	abnormal male (12)	24.23 (24.08–24.52)		
	normal female (144)	17.26 (16.65–18.20)	0.0	5.62×10^{-11}
	abnormal female (16)	26.61 (25.60–27.81)	0.0	5.62×10^{-11}
Average absolute strength	normal male (28)	21.13 (19.63–29.53)	64.0	0.002
	abnormal male (12)	29.80 (26.13–35.23)		
	normal female (144)	11.70 (9.07–15.81)	1328.0	0.318
	abnormal female (16)	11.57 (10.37–12.56)		
Relative Strength	normal male (28)	1.27 (0.99–1.67)	160.0	0.824
	abnormal male (12)	1.23 (1.09–1.44)		
	normal female (144)	0.70 (0.50–0.85)	2000.0	1.42×10^{-6}
	abnormal female (16)	0.41 (0.36–0.48)		

n= Number, %= percentage

Figures 1 and 2 provide boxplot visualizations of these results, illustrating the distribution of median, interquartile range, and outliers for the key variables. **Figure 1** displays boxplots for age and BMI across all groups. While age distributions were comparable across groups, BMI was notably higher in both abnormal males and females relative to their normal counterparts. **Figure 2** presents boxplots for absolute handgrip strength (HGS)" and relative strength. Absolute handgrip strength (HGS)" was higher in abnormal males compared to normal males, while relative strength was significantly reduced in abnormal females compared to normal females. These findings highlight pronounced differences in anthropometric and strength-related variables associated with abnormal bodyweight status, particularly in BMI, weight, and measures of strength, with patterns differing by gender.

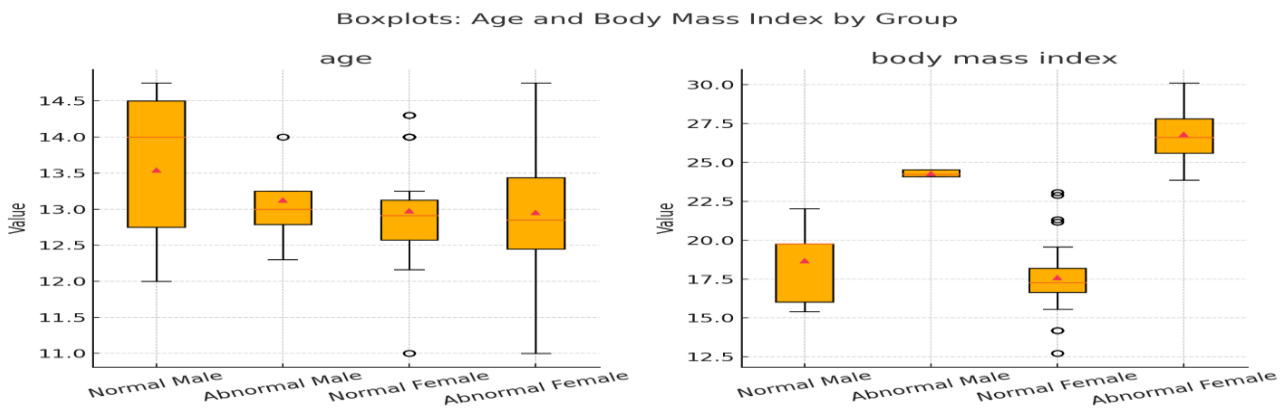

Figure 1

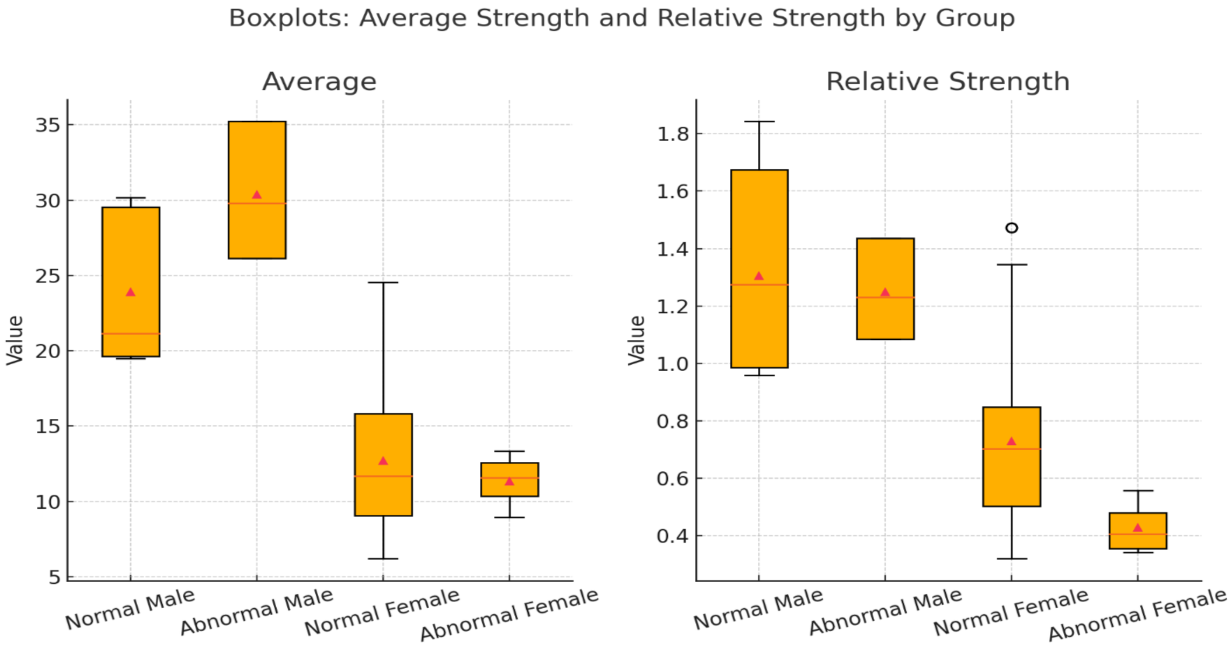

Figure 2

Discussion

This study analyzed the relationship between teenage obesity and hand grip strength, with a focus on sex differences. Compared with normal-weight participants, abnormal weight individuals presented substantially greater absolute hand grip strength; however, their relative hand grip strength was significantly lower. Manzano-Carrasco et al. (2023) reported that absolute grip strength increased with BMI, whereas relative strength decreased because excess adiposity negatively impacted muscle function. This conclusion aligns with their findings, although Manzano-Carrasco adds cardiorespiratory fitness and muscle-to-fat ratio analysis founding that that muscle-to-fat and handgrip strength (HGS) strength-to-BMI ratios are stronger predictors of youth fitness.

Men exhibited superior performance than women at both weight categories in both absolute and relative hand grip strength. These findings corroborate the work of Johnson and Reed (2023), who identified muscle mass distribution and hormonal variables as factors contributing to the observed variance. Compared with their normal-weight counterparts, abnormal weight males presented significantly greater absolute grip strength, whereas females with abnormal weight have lower relative grip strength than those with normal weight. These findings indicate that the positive effects of obesity on Hand grip strength may be more pronounced in males. This result is consistent with previous research by Wind et al. (2010), who also found that higher body weight in boys was associated with greater absolute grip strength, while this association was less evident in girls[24].

Our findings indicate that obesity diminishes muscle efficiency in comparison with previous studies. Palacio-Agüero et al. (2020) demonstrated that abnormal weight adults exhibit greater absolute muscle force but diminished functional strength. These findings indicate that relative hand grip strength is a more accurate measure of functional muscle performance in adolescents than absolute strength is.

The cross-sectional design of this study limits the ability to infer causality. Body mass index (BMI), which does not consider body composition, was utilized to assess adiposity. Future studies should employ direct metrics such as DEXA to enhance the understanding of the relationship between fat and muscle mass and their impact on strength.

Conclusion

Increased body weight enhances absolute grip strength in males, while in females it may lower strength relative to BMI, highlighting the importance of considering both gender and body composition when assessing muscle strength in adolescents.

DECLARATIONS

- **Consent to publish:** I certify that each author has given their consent to submit the work.
- **Competing interests:** None.
- **Funding:** No fund.

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