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Correlation Between Body Mass Index, Manual Dexterity and Handgrip Strength in School Aged Children

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ABSTRACT

Background: Childhood obesity and overweight have been related to a number of ailments and health issues. The human hand performs the challenging everyday chores and is the most engaging and energetic portion of the upper limb. An essential factor in assessing hand function is dexterity.

Objectives: To investigate the relation between body mass index (BMI), manual dexterity and handgrip strength in school aged children having normal weight, overweight or obesity.

Subjects and Methods: One hundred and five primary school children divided into thirty-five students having normal weight, thirty-five overweight students and thirty-five obese students, from both sex and ranging in age from 9 to 11 years, participated in the study. They were selected from governmental primary school in Shibin Alaqanater, Qalyubia Governorate. For assessment of BMI, the height and weight were measured. The assessment of manual dexterity was carried out by using Bruinink-Oseretsky test for motor proficiency 2nd edition (BOT-2) and handgrip strength (HGS) was assessed by handheld dynamometer.

Results: BMI and HGS showed a mild positive link, while BMI and manual dexterity showed a weak positive non-significant correlation.

Conclusion: It is concluded that no correlation was found between BMI and manual dexterity but due to the correlation between BMI and HGS it's recommended that HGS regularly measured in school aged children.

Keywords: BMI, Handgrip strength, Manual dexterity and school aged children.

INTRODUCTION

Young people make up the core of any country since they often exhibit higher levels of exercise and healthier lifestyles. The dominant hand makes up the majority of hand usage in daily life. The hands and forearms must be very active in order to undertake many daily activities and athletic feats. Some tasks requiring physical exertion and endurance necessitate the use of these muscles [(1)]. Children's physical strength is negatively correlated with metabolic and cardiovascular disease biomarkers, and positively correlated with general health, bone health, and self-esteem [(2)].

The simplest and most widely accepted method for determining relative body fatness is the BMI. Body fatness is often defined as a measure of weight in relation to height and is typically accepted as a reliable indicator of adiposity [(3)].

An imbalance between daily energy intake and expenditure that causes excessive weight growth is what causes obesity. Numerous variables, including genetic, cultural, socioeconomic, low physical activity, sleeplessness, eating patterns, endocrine diseases, medicines, food ads, and energy metabolism, contribute to its occurrence [(4)].

According to some epidemiologists, 20% of the world's population will be obese by 2030, defined as having a BMI above 30 kg/m^2 for adults or a BMI below the 95th percentile for their age and sex for children between the ages of 2 and 18. Checking waist size and body composition is also crucial. Increased risk of cancer, stroke, metabolic illness, heart failure, and other cardiovascular disorders are all associated with obesity [(5)].

One of the nations with an obesity and overweight health issue is Egypt. With a percentage of over 35% of the total population, it has the highest rate of overweight and obesity in the whole globe [(6)]. **Salem *et al.*** [(7)] reported that among Egyptian youngsters, the prevalence of obesity was 14.7% for boys and 15.08% for girls.

The human hand is an essential and unavoidable organ. Its activities range from fine to gross motor ones. High levels of hand activity are required for several daily tasks and sporting events. Grip strength depends on the strength of the hand and forearm muscles [(8)]. The term "handgrip strength" (HGS) refers to the maximum force produced by the contraction of both intrinsic and extrinsic hand muscles, which causes the hand joints to flex [(9)]. The handgrip is an essential part of human function and a distinctive characteristic that sets humans apart from monkeys [(10)].

Dexterity is typically described as the ability to synchronise minor muscle movements with the eyes, hands, and fingers [(11)]. The capacity of a person's hands to quickly move items and coordinate their fingers is known as manual dexterity [(12)]. An essential factor in assessing hand function is dexterity. These abilities are crucial for adults, but much more so for kids, whose physical and functional development is greatly influenced by their dexterity development [(13)].

Children who attend school need to have strong handgrips and good hand dexterity because the majority of their skilled tasks throughout the school day use their hands. When compared to kids with normal BMI, having a high BMI may have an impact on a child's hand strength and dexterity. Children's physical activity will

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be impacted, and they may fall behind their peers in all activities at school [14].

This study aimed to investigate the relation between body mass index, manual dexterity and handgrip strength in school aged children having normal weight, overweight or obesity.

SUBJECTS AND METHODS

Study design

Cross sectional observational correlational study that was conducted from 2022 to 2023.

Subjects:

One hundred and five primary school children divided into thirty-five students having normal weight, thirty-five overweight students and thirty-five obese students, from both sex and ranging in age from 9 to 11 years, participated in the study. They were selected from governmental primary school in Shibin Alaqanater, Qalyubia Governorate. Musculoskeletal issues, such as fractures, prostheses, finger, arm, or shoulder inflammation, vision or hearing impairments, motor, behavioural, or neurologic abnormalities, learning difficulties, congenital defects, or medical conditions that might interfere with the study were all grounds for a student's excluded from the study.

Instrumentation:

For assessment of BMI, height in (cm) and weight in (kg) were measured using the standard weight and height measuring scale. The Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) was used to evaluate manual dexterity [15]. Using an electronic dynamometer (CAMRY Dynamometer, model EH101, Guangdong, China), handgrip strength was calculated in kilogrammes [16].

Procedures:

For assessment of BMI

Height assessed as follows: All the participants were asked to stand without footwear, knees straight, and heels touching the ground, feet slightly apart, the trunk balanced over the waist not leaning backward or forward and looking straight ahead. The height was recorded from the heel to the vertex (most high point of the skull). It was recorded to the last completed 0.1 cm.

Weight was assessed as follows: First the scale was placed in a firm stable surface. All the participants were asked to remove any items in their pockets and remove footwear. They were asked to stand on the middle of the scale, not holding onto a wall or a table and their arms held at their side and looking straight ahead. We waited until the scale settle at a reading and recorded it the nearest 100 grams. The BMI was then computed by dividing the body mass in kilogrammes by the square of the height in metres [17]. Using the CDC's online Child and Teen BMI Calculator, which displays the BMI percentile throughout the BMI calculation and may be found at http://nccd.cdc.gov/dnpabmi/Calculator.a spx. We then put the estimated BMI for boys and girls (2–20 years old) on the Body Mass Index for Age Percentile Chart (CDC Growth Charts), determining the weight status category for the determined BMI-for-age percentile.

For Manual dexterity assessment by Bruininks-Oseretsky Test of Motor Proficiency (BOT-2):

The BOT-2 is a test that is administered on an individual basis that examines a variety of fine and gross motor control abilities in people between the ages of 4 and 21. It is intended to offer practitioners with excellent reliability and validity, including occupational therapists, developmental adaptive physical therapists, educational instructors, and researchers [15]. For the whole form total motor composite and short form, it has fair to good inter-rater and test-retest reliability [18]. Manual dexterity was one of the subtests examined in this study. It involved goal-directed exercises including reaching, gripping, and bimanual coordination with tiny items. Pick up pennies and put them in the box, string little blocks, sort cards, put pegs in a pegboard, and make dots in circles are some of the activities on the list. The youngster was instructed to do the work as soon as possible since emphasis is placed on the correctness and timeliness of the things. The timed tasks more accurately distinguish levels of dexterity by considering speed [15].

For handgrip strength assessment:

The CAMRY EH101 dynamometer offers outstanding validity and dependability. This tool may be used to measure grip strength since it is accurate, affordable, and useful [16]. The participants placed their arms in accordance with the instructions of the American Society of Hand Therapists while seated, with the forearm and wrist in a neutral posture, the elbow flexed at 90 degrees, and the shoulder adducted and neutrally rotated. Each participant maintained maximum grip contraction while squeezing the dynamometer handle as hard as they could. With a 30-second break in between each trial, this activity was performed three times. The three trials' average scores were computed. Reduced grip was indicated by lower scores [19].

Ethical Considerations:

The study protocol was approved by the Faculty of Physical Therapy Ethics Committee, Cairo University (No: P.T.REC/012/004242) and filed on ClinicalTrials.gov (with ID number: NCT05759702). Before children took part in this study, written informed consent of all the caregivers of the participants was obtained. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

SPSS version 25 for Windows was used for all statistical calculations. The demographic details of the participants and the data gathered were shown using descriptive statistics. Mean±Standard deviation (SD),

and range were used to express quantitative data. Frequency and percentage were used to express qualitative data. BMI, manual dexterity, and handgrip strength were investigated in connection to one another using the Pearson correlation coefficient test. P< 0.05 was used as the significance cutoff for statistical testing.

RESULTS

Subject characteristics:

One hundred and five school aged children (60 girls and 45 boys) participated in this study group. Participant characteristics is presented in table (1).

Table (1): Participant characteristics

	Mean ± SD	Maximum	Minimum
Age (years)	10.26 ± 0.65	11	9
Weight (kg)	43.06 ± 8.33	59	28.8
Height (cm)	141.73 ± 6.21	155	130
BMI (kg/m²)	21.28 ± 3.21	27.2	15.5
	N	**%**	
Sex distribution, n (%)			
Girls	60	57.1	
Boys	45	42.9	
Weight status, n (%)			
Normal	35	33.3	
Overweight	35	33.3	
Obese	35	33.3	
Dominant side, n (%)			
Right	102	97.1	
Left	3	2.9	

SD: Standard deviation

- Manual dexterity and hand strength of participants (Table 2):

Table (2): Descriptive data on participants' physical dexterity and hand strength

	Mean ± SD	Minimum	Maximum
Hand strength (kg)	65.56 ± 4.68	57	78
Dominant hand	15.49 ± 3.38	9.03	25.8
Non-dominant hand	14.48 ± 3.28	7.3	25.37
Manual dexterity	11.52 ± 2.73	6	19

SD: Standard deviation

Correlation between BMI, manual dexterity and hand strength:

The correlation between BMI and hand strength was positive significant correlation with dominant hand and with non-dominant hand. The correlation between BMI and manual dexterity was weak positive non-significant correlation (Table 3).

Table (3): Correlation between BMI, manual dexterity and hand strength

	BMI (kg/m²)		Manual dexterity	
	r – value	**P-value**	**r – value**	**P-value**
Dominant hand strength	0.252	0.009*	0.329	0.001*
Non-dominant hand strength	0.233	0.017*	0.230	0.018*
BMI (kg/m²)			0.117	0.503

r value: Pearson correlation coefficient

DISCUSSION

One of the most debilitating and socially unacceptable illnesses in children and adolescents, obesity is a severe public health issue. Childhood obesity frequently lasts into adulthood, which marks the beginning of a potentially lifelong chronic condition. It is a risk factor for a number of adult morbidity and mortality issues. The most frequent short-term effects of pediatric obesity are psychological in character, despite the fact that being overweight or obese is connected with a wide range of serious medical repercussions, even at a young age [(20)].

The main goal of this study was to look at the relationship between BMI and handgrip strength and manual dexterity because the previous study mainly concentrated on BMI and gross motor efficiency in children.

Because grip strength and manual dexterity are needed for both work and play and leisure activities, this study will focus on handgrip strength and manual dexterity. Additionally, 60% of academic tasks demand dexterity and fine motor abilities [(21)].

The current study's findings showed that handgrip strength and BMI had a weak positive significant association. One explanation is that people who are fat have more muscle mass, which is a key factor in determining muscle strength. Additionally, carrying and sustaining the heavier weight has a training effect that can help obese people' muscles grow [(22)].

The findings of the current study fall in accordance with the results of more recent study done by **Kotecha and Desai** [(23)] concerning connection of BMI with handgrip and pinch grip strength in children of 6-12 years. They discovered that percentile has a very weakly significant positive correlation with pinch strength and a very weakly significant positive association with handgrip strength. This suggests that children's pinch and handgrip strength will grow as their BMI rises.

The findings of the current study supported those of **Duman and Subaşı [(24)],** who investigated the effect of pinch, grip, and upper extremity muscle strength on fine

motor skills and discovered a link between all upper extremity features, including grip strength, pinch strength, and fine motor abilities. Grip and pinch strength were shown to have positive associations.

The findings of a prior research by **Hammed and Obaseki [(1)],** who looked at how handgrip strength and endurance related to BMI in Nigerian teenagers who appeared to be in good health, can also be used to corroborate the conclusions of the current investigation. They proposed a strong positive correlation between BMI and HGE and HGS. This suggests that having a higher BMI would lead to improved HGS and HGE. This may be due to a larger percentage of skeletal muscle mass rather than a higher percentage of fat mass, which can contribute significantly to body heaviness and lead to better or higher HGS and HGE.

Our findings contradicted those of **Dhananjaya *et al.* [(25)]** who discovered a mild negative correlation between BMI and HGS in participants with obese BMIs and a strong negative correlation in persons with normal BMIs. Due to the reduction of muscular strength caused by the buildup of fat, as well as the fact that obese participants had more type IIb muscle fibres than their lean counterparts, the HGS and BMI were likewise marginally negatively connected in overweight female participants. Type I and type II fibres are negatively and positively linked with fat mass, respectively.

The results of our study were not consistent with **Lad *et al.* [(26)]** who suggested that the overweight population had less HGS than the normal weight and the underweight populations.

Children who were obese, overweight, or normal weight performed similarly on manual dexterity tasks. One explanation for this might be that since all manual dexterity tasks are performed while seated, no movement of the extra body mass is required, and balance control is not overly taxed. It has been proposed that whether a job necessitates projecting body mass across space or sustaining movement, where the body moves against gravity, influences the association between BMI and motor abilities. Fine motor abilities appear to be relatively unaffected by the limitations imposed by excessive body weight, contrary to what has been found to be the case for dynamic body motions in obese children [(27)].

The findings of the present investigation are consistent with those of a study by **DuBose *et al.* [(28)]** who discovered no relationship between fine motor abilities (measured by the Manual Dexterity subscale of the Movement Assessment Battery for Children, 2nd Edition) and body mass index. It makes sense considering how passive fine motor abilities are.

The findings of the present study are consistent with those of a study by **Truter and Du Toit [(29)]** who found no conclusive associations between obesity and fine motor control (fine motor precision and fine motor integration) or fine motor coordination (manual dexterity and upper-limb coordination activities) abilities.

The current study's findings were in agreement with those of **Faught *et al.* [(30)],** who investigated whether a person's relative body fat affects how well they perform on the Movement Assessment Battery for Children, 2nd Edition. They discovered that manual dexterity is not considerably impacted by relative body fat.

The findings of our study did not agree with those of **Katani *et al.* [(31)]** they conducted a study to determine the differences in preschool children's fine motor abilities between normal weight and overweight children, as well as the relationship between preschool children's fine motor skills and BMI categories. The findings revealed a substantial inverse relationship between BMI and hand dexterity, fine motor integration, and the overall outcome of fine motor abilities.

Our research's findings did not agree with those of **Denat and Kuzgun [(32)]** who conducted a descriptive and analytical study to characterise nurses' physical dexterity and the elements that influence it. 96 nurses who worked in an academic and research hospital in the south of Turkey made up the sample for this descriptive and analytical study. An online poll and the Purdue Pegboard exam were used to obtain the data. According to the study's findings, there was a strong inverse association between the nurses' BMI and manual dexterity.

CONCLUSION

From the obtained result of this study, it is concluded that no correlation was found between BMI and manual dexterity but due to the correlation between BMI and HGS it's recommended that HGS regularly measured in school aged children.

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Competing interests: Nil.

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