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Correlation of BMI with Hand Grip and Pinch Grip Strength in Children of 6-12 Years

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ABSTRACT

Background And Objective: Many activities of daily living involve the use of the hands with various hand grips for doing tasks. The nutritional status can influence the muscle quality and so, the muscle strength. The association between the muscle strength and underweight and the muscle strength and overweight/obesity were studied separately by many researchers, but very few studies have investigated the longitudinal assessment of the BMI with the muscle strength in various BMI ranges in children. Therefore, the purpose of the study was to determine whether BMI is associated with hand grip and pinch grip strength in typically developing children of 6-12 years of age. The objective of the study was to analyse the correlation between BMI with hand grip strength and pinch grip strength.
Method: Total 330 typically developing school-going children from 6-12 years were taken. BMI percentile was measured according to their age, height, and weight. Hand grip strength and Pinch grip strength were measured.
Result: Spearman correlation test was used to analyse the data. A significant and weak positive correlation was found between BMI percentile and Hand grip strength($p<0.05$). A significant and very weak positive result was found between BMI percentile and Pinch Grip strength.
Conclusion: The study leads to the conclusion that There is weak positive correlation between BMI percentile and HGS. There is very weak positive correlation between BMI percentile and PGS There is strong correlation between HGS and PGS.

Keywords: BMI, Hand grip strength, Pinch grip strength, school-age children.

INTRODUCTION

Nutrition pattern distribution in Indian children is sliding from undernutrition to dual nutrition burden. [1,2] Dual burden is unique problem where at one end of the spectrum have obesity and overweight and while at the other end have malnutrition and underweight. Since the amount of body fat per se is difficult to determine exactly, for practical use, the body mass index (BMI) being an quick screening tool is used to track obesity, overweight, normal weight and underweight in children. [3,4] Calculating BMI in children is distinct from that of adult, as it is dependent not only on height and weight, but also age and gender, owing to the variation in maturing body. Therefore, in children, BMI is calculated and compared with others of same age to determine the percentile of age.[5] Centre for diseases control and prevention (CDC) defined BMI categories as percentile in children. Centre for diseases control and prevention (CDC) charts classify underweight as less than the 5th percentile, healthy weight as 5th percentile to less than 85th percentile, overweight as 85th to less than the 95th percentile and obese as 95th percentile or greater.[5] Motor capacity can be defined as the quality of coordinating a person's

movements when performing motor skills ranging from gross motor skills to fine motor skills.[6] Nutrition and weight status of an individual can influence the muscle quality and so, the muscle strength.[7,8,9] Decreasing nutrient intake leads to a loss of body-wide protein, which is preferentially lost in muscle mass, the body's largest store of protein. Since muscle function is closely correlated with total body protein, somatic cell mass, anthropometric arm muscle mass, and even body mass index (BMI), weight loss and obesity inevitably lead to decreased muscle strength.[8,9,10] Decreased muscle strength in underweight can also be explained on the basis of the energy deficiency.[11]Conversely, Obese subjects have been shown to possess fewer type I and more type IIb muscle fibers than lean people, as fat mass correlates inversely with type I fibers and positively with type II fibers. [8] Thus, reduced muscle function may be directly impacted by delays in fine motor, gross motor, and cognitive development in early childhood. [8,12] The handgrip strength has evolved as an important tool for the assessment of the nutritional status; it is being considered as a reliable marker of the muscle quality.[8,9,13]Along with hand grip strength pinch grip strength is important so that Hands can perform heavy activities and also enable to perform extremely gentle, skilful, and precise activities. Inadequate hand grip strength and pinch grip strength may lead to functional limitations which can lead to a reduction in essential daily life activities and affects the quality of life, as hand function is important for most fine motor activities involving the upper extremities, such as eating, writing, carrying, lifting objects, opening or closing doors, etc.[10] The equipment used for the evaluation of hand strength consisted of two dynamometers: Baseline® hydraulic dynamometers (r=0.9997) for the measurement of palmar grip strength and Baseline® pinch gauge (r=0.9998) for the measurement of pinch grip.[10] Most of the previously done studies focus exclusively on gross motor skills when examining the link between motor competence and weight status in children. [14,15] However, fine motor skills are equally important and can be seen as prerequisites to successfully engage in activities of daily living. Also, most of these studies are done in either the adult or the old population.[16] The association between muscle strength and underweight and muscle strength and overweight/obesity has been studied separately by many researchers, but very few studies have investigated the evaluation of BMI with muscle strength in different BMI ranges. To our knowledge, there is no study conducted regarding the possible weight related differences in hand grip strength and pinch grip strength in conduct to fine motor efficacy. Therefore, the aim of this study was to investigate the correlation between grip strength and grip strength when considering fine motor strength with different BMI percentiles in 6 to 12 years of children.

METHOD

Ethical clearance was obtained from institutional ethical committee. School going Children were screened according to the inclusion and exclusion criteria. Nature and purpose of the study was explained to the subject in detail, in the language they understood. All the subjects acknowledged their understanding of the study and their willingness to participate by providing signed assent form. Assent form was signed from parents/ guardian/ child for the participation of the children following inclusion and exclusion criteria of the study. This study included typical developing children from 6-12 years of age of both male and female gender and falling under all BMI subgroup criteria. The study excluded children with any history of upper limb fracture in past 3 years or any upper limb deformity or involved in any active muscle training exercise for upper limb or had any neurological, cardiovascular or musculoskeletal disorders, A total of 330 subjects both boys and girls from age group 6-12 years were taken. The height of the selected children was measured using stadiometer and the weight was measured

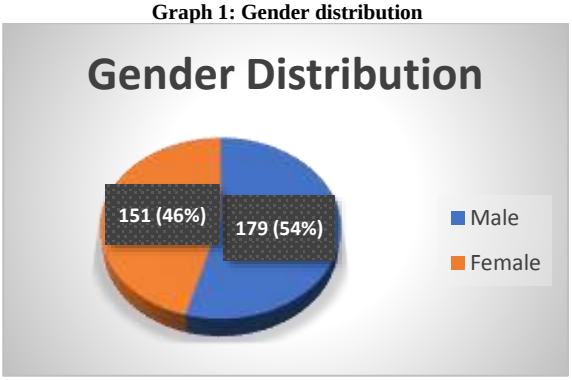
using analog weighing machine. Based on CDC (centres of diseases control and prevention) criteria BMI was further calculated and children were subcategorized in to 4 groups that is underweight, normal weight, overweight and obese. Hand grip strength and pinch grip strength were measured for all 4 groups using baseline hydraulic hand dynamometer and baseline pinch gauge respectively. Verbal instructions were given while measuring the grip strengths. Hand grip strength were first performed followed by pinch grip strength. An average of 3 trials were recorded for both the instruments. Adequate rest periods between the trials were provided to avoid the muscle fatigue.

RESULT

The statistical software SPSS version 20.0 was used for the analysis of the data and Microsoft word and excel have been used to generate graphs and tables.

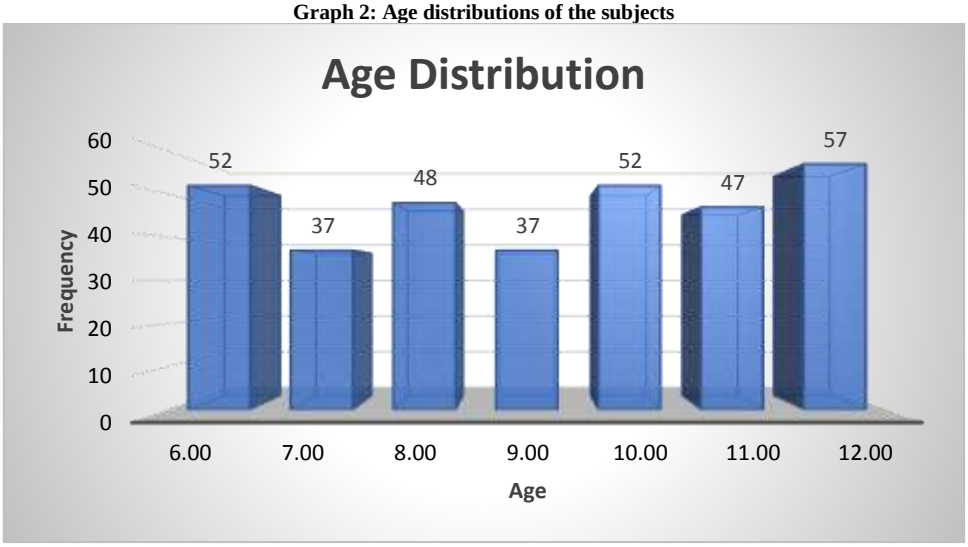
Total 330 subjects participated in the study of age 6-12 years from which 151 were female and 179 were males.

Graph 1: Gender distribution



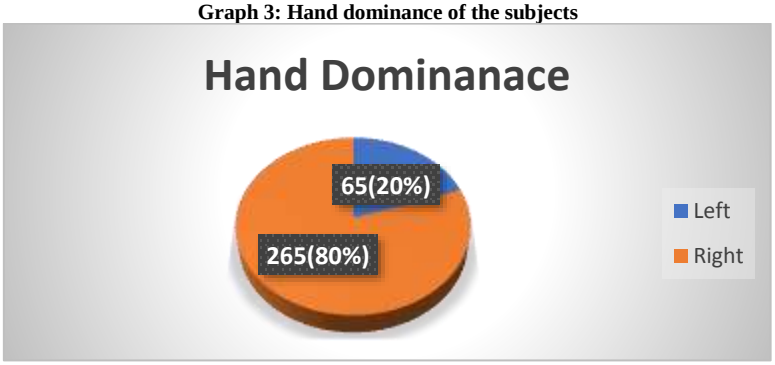
(Graph 1 shows gender distribution of subjects in which 45.8% were female and 54.2% were male.)

Graph 2: Age distributions of the subjects



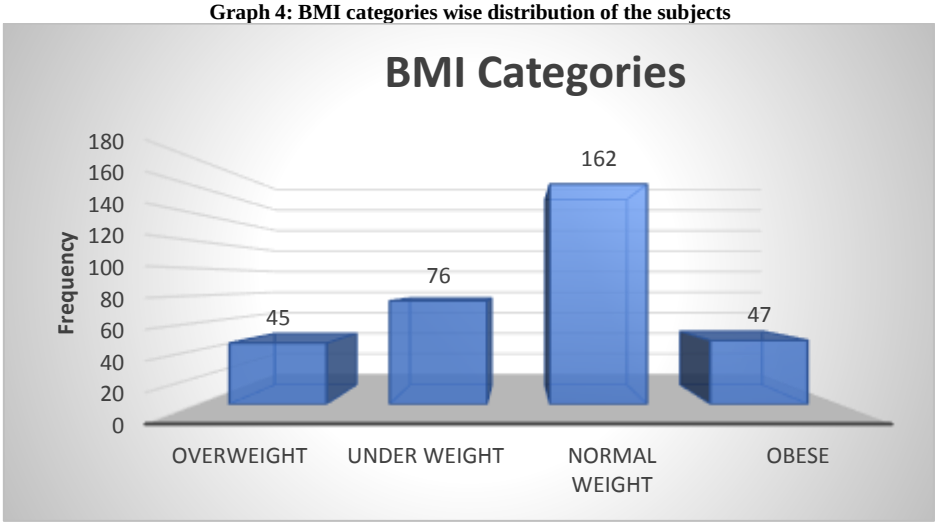
(Graph 2 shows different age groups taken in the study and the no of subjects present in each age group.)

Graph 3: Hand dominance of the subjects



(Graph 3 shows out of 330 subjects 80.3 percent were right handed and 19.7 percent were left handed)

Graph 4: BMI categories wise distribution of the subjects



(Graph 4 shows out of 330 subjects 13.6% were overweight, 23% were under weight,49.1% were normal weight and 14.2% were obese.)

Table 1: Descriptive Statistics according to BMI Categories

	Under Weight			Normal Weight			Overweight			Obese		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Age	76	8.34	2.11	162	9.42	2.06	45	9.53	2.02	47	8.96	1.79
Height	76	127.20	12.93	162	135.85	13.66	45	135.92	11.98	47	132.98	15.20
Weight	76	21.11	5.33	162	32.70	13.84	45	38.14	9.36	47	45.15	11.74
BMI	76	1.48	1.03	162	46.57	27.40	45	89.47	2.95	47	97.65	1.33
HG	76	6.16	3.96	162	10.57	6.74	45	10.31	4.57	47	9.68	4.77
PG	76	3.09	0.87	162	3.97	1.18	45	4.31	3.65	47	3.38	1.12

(Table 1 shows mean and SD for variables in BMI categories of the subject.)

Table 2: Age wise descriptive Statistics.

Age		No of subjects	Mean	Std. Deviation
6	HG	52	3.54	2.10
	PG	52	2.46	0.66
7	HG	37	6.53	3.26
	PG	37	2.97	0.68
8	HG	48	7.38	2.89
	PG	48	3.41	0.92
9	HG	37	7.99	2.77
	PG	37	3.38	0.86
10	HG	52	10.32	3.59
	PG	52	4.38	3.31
11	HG	47	12.11	4.85
	PG	47	4.33	1.02
12	HG	57	16.00	7.73
	PG	57	4.81	0.99

(Table 2 shows mean and SD for HGS and PGS in different age groups of the subject.)

Table 3: Gender wise descriptive Statistics.

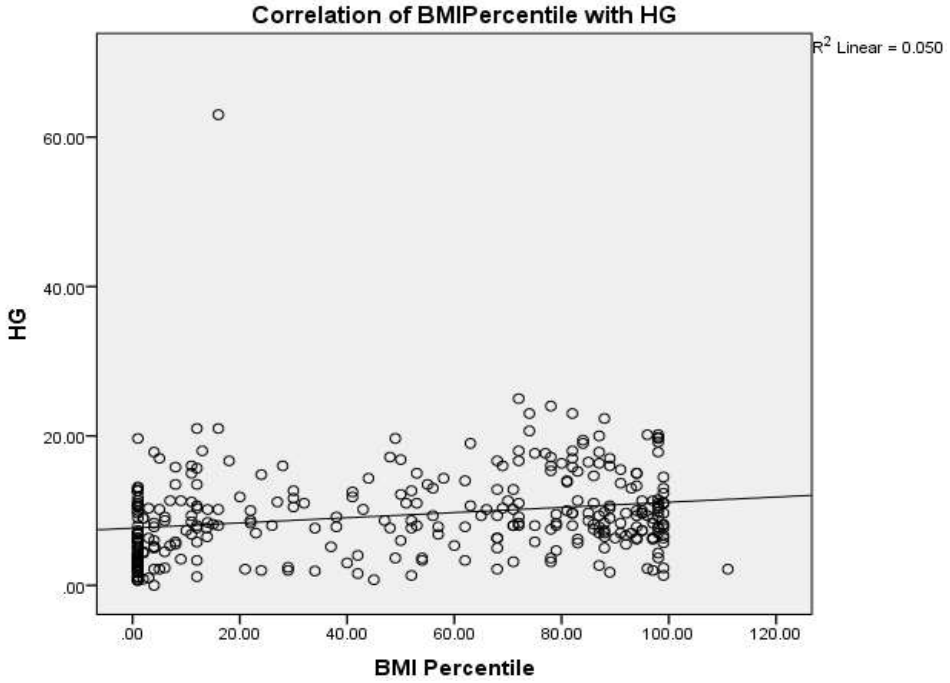
Descriptive Statistics				
Gender		No of subjects	Mean	Std. Deviation
Male	HG	179	9.74	5.13
	PG	179	3.94	2.12
Female	HG	151	8.95	6.77
	PG	151	3.48	1.07

(Table 3 shows mean and SD for HGS and PGS in both the gender groups of the subject.)

Table 4: Correlation of BMI percentile with hand grip strength

TEST	N	r-value	P value
Spearman correlation	330	0.282	P<0.05

Graph 5: Correlation of BMI percentile with HGS

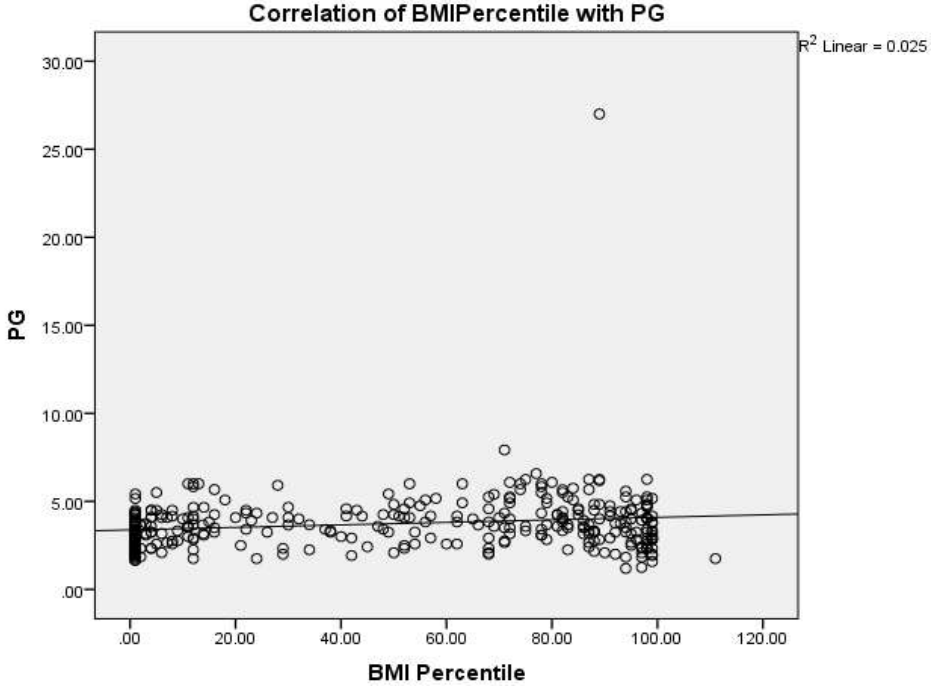


(Table 4 and graph 5 shows there is weak positive and significant correlation between BMI and hand grip strength.)

Table 5: Correlation of BMI percentile with pinch grip strength

TEST	N	r-value	P value
Spearman correlation	330	0.160	P<0.05

Graph 6: Correlation of BMI percentile with PGS

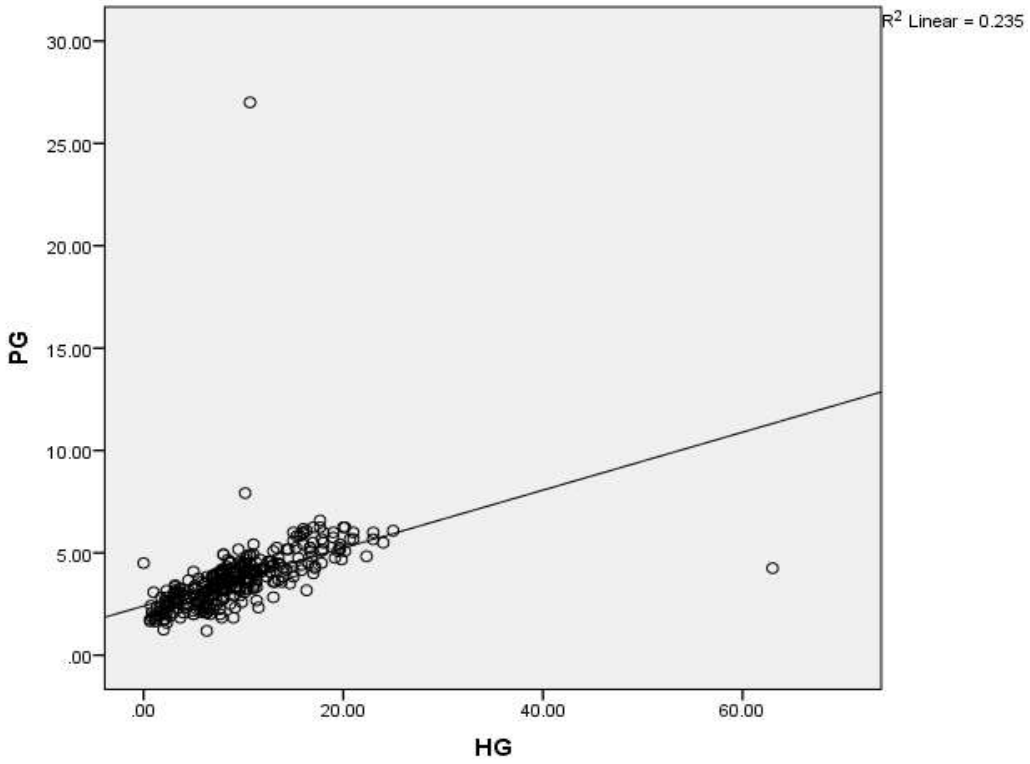


(Table 5 and graph 6 shows there is very weak positive and significant correlation between BMI and pinch grip strength.)

Table 6: Correlation of HGS and PGS

Correlations				
			HG	**PG**
Spearman's rho	HG	Correlation Coefficient	1.000	.818**
		Sig. (2-tailed)		<0.001
		N	**330**	**330**

Graph 7: Correlation of HGS with PGS



(Table 6 and graph 7 shows there is strong positive and significant correlation between hand grip strength and pinch grip strength.)

DISCUSSION

Childhood underweight along with overweight and obesity is a growing epidemic in developing countries. Weight status can alter the muscle quality and also the muscle strength. [7,8]

In order to cope with the demands of daily life, full function and adequate strength of the hand is necessary. The hand is a complex and well differentiated musculoskeletal structure which has the largest representation in the nervous system in relation to its size.[17]

One of the important functions of hand is the ability to grip an object. If the ability to hold the object is hampered then performance of activities of daily living is affected.[10]

Hand grip strength testing is suggested as a component of the physical fitness test, because hand grip strength can be used to assess the general muscle strength.[18]

Given the previous study mostly focused on BMI and gross motor efficiency in children, The primary purpose of this study was to investigate the association between BMI percentile with hand grip strength as well as pinch grip strength in school aged children falling either in underweight, normal weight, overweight and obese children.

Our secondary aim was to examine weather hand grip strength and pinch grip strength mean scores differs according to weight status of the child.

In our study total 330 children (151 female and 179 male) of 6-12 years of age were taken. The choice of minimum age for the study was based on the concept of normal psychomotor chronological development. Mean age of underweight, normal weight, overweight and obese was 8.34±2.11, 9.42±2.06, 9.53±2.02 and 8.96±1.79 respectively.

Considering dominancy of hand in the study, 80.3% of the subjects were right-handed and 19.7% were left-handed. Handedness of the subject was check by asking them to write their name into the Paper.

Differentiation the subjects into the different BMI percentile categories, our study had 23% underweight subjects,49% normal

weight subject, 13.6% of overweight subjects and 14.2% obese subjects.

Mean BMI percentile for underweight, normal weight, overweight and obese was 1.48±1.03,46.57 ±27.40,89.47± 2.95 and 97.65± 1.33 respectively.

Mean HGS scores for underweight, normal weight, overweight and obese was 6.16±3.96, 10.57 ±6.74, 10.31± 4.57 and 9.68± 4.77 respectively.

Mean PGS scores for underweight, normal weight, overweight and obese was 3.07±0.8, 3.97 ±1.18, 4.31± 3.65 and 3.38± 1.22 respectively.

As already stated in previous studies on children by Ager et al. 1984; Broadhead et al 1974 that there is positive relationship between hand strength and age, similarly we also found that both grip and pinch strength increases steadily with chronological age, and males have consistently higher mean of HGS score and mean of PGS scores than females within each age group. [19,20] Mohammadian M et al. 2014 also found that there are significant differences in the pinch grip strength of males and females which can be due to differences in gender specific muscle fibers [21] Prajakta Namjoshi et al 2017 showed that palmar pinch grip strength is more in males than in females.[22]

Results in the present study demonstrated that that percentile has a weak positive significant association with hand grip strength and very weak positive significant association with pinch strength ($p < 0.05$). This suggest that as BMI increases the hand grip strength and pinch grip strength in children will increase.

Supporting our results, same significant positive association was found by Apovian et al 2002 he stated that greater hand grip strength is related to the higher BMI. [23]

Duman Ç, Subaşı et al 2020 researched Effects of Pinch, Grip and Upper Extremity Muscle Strength on Fine Motor Skills and showed that all parameters of the upper extremity such as grip strength, pinch strength and fine motor skills were related to each other. While grip strength and pinch strength had a positive correlation, they correlated negatively with fine motor movement.[24]

Reason that the hand muscle strength is negatively related with the fine motor skills could be because Muscles that control fine movements and require precise but low strength have fewer fibers per motor unit, while the large muscles that control gross motor movements requiring greater strength may contain greater numbers of muscle fibers.[25]

Same results have been repeatedly shown by, Nikolaidis et al 2012 that bilateral grip strength was positively associated with BMI in sports population. [26] Keevil VL et al 2015 also suggested that larger overall body mass, indicated by higher BMI, is associated with stronger grip strength.[27] Kun-Hsi Liao et al 2016 conducted a study which included 200 participants who were divided into three groups based on their BMI. HGS was assessed using a hand-held Jamar dynamometer, and showed that there were significant differences in hand grip strength among low, medium, and high BMI subjects. He also stated that gender was the most significant factor affecting HGS.[28]

Contrast to our result many research has suggested that negative association of BMI with grip strengths. (Kristina norman et al 2011, Windsor Ja et al 1988) reported that reduction nutritional intake results in compensatory loss of whole-body protein, most likely from muscle. Starvation results into significantly lower grip strength and altered adductor pollicis muscle function. [8,29]

A study conducted by Tanner CJ et al 2002 stated that obese subjects have been shown to possess fewer type 1 and more type 2b muscle fibers. As fat mass corelated inversely with type 1 fibers and positively type 2 fibers, these structural changes in muscle are suggested to reflect loss of contractile elements.[30]

From the previous studies taken up by Massy et al 2011, he stated that "The chronically undernourished groups have significantly lower handgrip strength than the underweight groups," both being

significantly less strong than the "well-nourished" groups of BMI higher than 18.5.[31]

Ravishakar P et al 2005 also found that hand grip strength was highest in normal weighted children when compared with other BMI groups.[32]

S. Pieterse et al 2002 in his study he concluded that that Handgrip strength was positively correlated to BMI (body mass index) and AMA (arm muscle area). The relative risk of impaired handgrip strength in individuals with poor nutritional status (BMI<18.5 kg/m^2) compared with those of adequate nutritional status. After controlling for potential confounders (gender, age and height), BMI remained a significant contributor to the variation in handgrip strength we also assume that the overall positive and statistically significant association between BMI percentile and hand grip strength and pinch grip strength could be due to large number of normal weighted subjects.[16]

When correlating hand grip strength and pinch grip strength in our result we found that both have significant strong positive correlation ($p<0.01$) which is similar to this was found by Alahmari KA et al 2019 in which BMI (r = 0.33 (M), 0.41 (F)) was significantly correlated with HGS in both boys and girls.[33]

This study concludes that BMI percentile has weak positive association with the hand grip strength and BMI percentile has very weak positive association with pinch grip strength in typically developing children from 6-12 years of age.

CONCLUSION

Our study leads to the conclusion that, there is weak positive correlation between BMI percentile and HGS and There is very weak positive correlation between BMI percentile and PGS. Besides there is strong correlation between HGS and PGS.

Future Recommendations

Future studies can be done with equal number of subjects for BMI percentile each category or with large number of sample size along with bifurcation of the age groups for more accurate results can be done. Also, Correlation of functional fine motor skills with hand grip strength and pinch grip strength can be carried out to get more in-depth knowledge regarding hand strength and ADL activities of child.

REFERENCES

1. Mathur P, Pillai R. Overnutrition: Current scenario & combat strategies. The Indian journal of medical research. 2019 Jun;149(6):695.
2. Jafar TH, Qadri Z, Islam M, Hatcher J, Bhutta ZA, Chaturvedi N. Rise in childhood obesity with persistently high rates of undernutrition among urban school-aged Indo-Asian children. Archives of disease in childhood. 2008 May 1;93(5):373-8.
3. Poskitt EM. Defining childhood obesity: the relative body mass index (BMI). Acta Paediatrica. 1995 Aug;84(8):961-3.
4. Rolland-Cachera MF, Sempe M, Guilloud-Bataille M, Patois E, Pequignot-Guggenbuhl F, Fautrad V. Adiposity indices in children. The American journal of clinical nutrition. 1982 Jul 1;36(1):178-84.
5. Kathy coultes. Children with obesity and role of physical therapist. Tecklin JS, editor. Pediatric physical therapy. Fifth edition. Lippincott Williams & Wilkins; 2008.pg 641-57.
6. D'Hondt E, Deforche B, De Bourdeaudhuij I, Lenoir M. Relationship between motor skill and body mass index in 5-to 10-year-old children. Adapted Physical Activity Quarterly. 2009 Jan 1;26(1):21-37.
7. Lad UP, Satyanarayana P, Shisode-Lad S, Siri CC, Kumari NR. A study on the correlation between the body mass index (BMI), the body fat percentage, the handgrip strength and the handgrip endurance in underweight, normal weight and overweight adolescents. Journal of clinical and diagnostic research: JCDR. 2013 Jan;7(1):51.
8. Norman K, Stobäus N, Gonzalez MC, Schulzke JD, Pirlich M. Hand grip strength: outcome predictor and marker of nutritional status. Clinical nutrition. 2011 Apr 1;30(2):135-42.
9. Dhananjaya JR, Veena HC, Mamatha BS, Sudarshan CR. Comparative study of body

mass index, hand grip strength, and handgrip endurance in healthy individuals. National Journal of Physiology, Pharmacy and Pharmacology. 2017;7(6):594.
10. Duruöz MT. Assessment of Hand Function. In Hand Function 2019 (pp. 43-53). Springer, Cham.
11. Delmonico MJ, Harris TB, Visser M, Park SW, Conroy MB, VelasquezMieyer P, Longitudinal study of muscle strength, quality, and adipose tissue infiltration. Am J Clin Nutr. 2009;90:1579–85
12. Ooi PH, Thompson-Hodgetts S, Pritchard-Wiart L, Gilmour SM, Mager DR. Pediatric sarcopenia: a paradigm in the overall definition of malnutrition in children?. Journal of Parenteral and Enteral Nutrition. 2020 Mar;44(3):407-18.
13. Prista A, Maia JAR, Damasceno A, Beunen G. Anthropometric indicators of nutritional status: implications for fitness, activity, and health in school-age children and adolescents from Maputo,Mozambique. Am J Clin Nutr. 2003;77:952–59.
14. Mak K, Ho SY, Lo WS, Thomas GN, McManus AM, Day JR, et al. Health-related physical fitness and weight status in Hong Kong adolescents. BMC Public Health. 2010;10:88.
15. Hulens M, Vansant G, Lysens R, Claessens AL, Muls E, Brumagne S. Study of differences in peripheral muscle strength of lean versus obese women: an allometric approach. Int J Obes. 2001; 25: 676-81.
16. Pieterse S, Manandhar M, Ismail S. The association between nutritional status and handgrip strength in older Rwandan refugees. Eur J of Clin Nutri. 2002;56: 933–939.
17. Angst F, Drerup S, Werle S, Herren DB, Simmen BR, Goldhahn J. Prediction of grip and key pinch strength in 978 healthy subjects. BMC musculoskeletal disorders. 2010 Dec 1;11(1):94
18. Wind AE, Takken T, Helders PJ, Engelbert RH. Is grip strength a predictor for total muscle strength in healthy children, adolescents, and young adults? European journal of pediatrics. 2010 Mar;169(3):281-7.
19. Ager CL, Olivett BL, Johnson CL. Grasp and pinch strength in children 5 to 12 years old. American journal of occupational therapy. 1984 Feb 1;38(2):107-13.
20. Broadhead GD. Dynamometric grip strength in mildly handicapped children. Rehabilitation literature. 1975 Sep 1;36(9):279-83.
21. Mohammadian M, Choobineh A, Haghdoost A, Hasheminejad N. Normative data of grip and pinch strengths in healthy adults of Iranian population. Iranian journal of public health. 2014 Aug;43(8):1113.
22. Namjoshi P, Kaur R, Mishra U, Sancheti P. Normative values of pinch strength in Pune, India population. Sch J Appl Med Sci. 2017;5(5B):1837-40.
23. Apovian CM, Frey CM, Wood GC, Rogers JZ, Still CD, Jensen GL. Body mass index and physical function in older women. Obesity research. 2002 Aug;10(8):740-7.
24. Duman Ç, Subaşı F. Effects of Pinch, Grip and Upper Extremity Muscle Strength on Fine Motor Skills. Age.;20(25):22-83.
25. Kuriki HU, Mello EM, De Azevedo FM, Takahashi LS, Alves N, de Faria Negrão Filho R. The relationship between electromyography and muscle force. INTECH Open Access Publisher; 2012 Jan 11.
26. Nikolaïdis P. Development of isometric muscular strength in adolescent soccer players. Facta universitatis-series: Physical Education and Sport. 2012;10(3):231-42.
27. Keevil VL, Luben R, Dalzell N, Hayat S, Sayer AA, Wareham NJ, Khaw KT. Cross-sectional associations between different measures of obesity and muscle strength in men and women in a British cohort study. The journal of nutrition, health & aging. 2015 Jan;19(1):3-11.
28. Liao KH. Hand grip strength in low, medium, and high body mass index males and females. Middle East Journal of Rehabilitation and Health. 2016 Jan 1;3(1).
29. Windsor JA, Hill GL. Grip strength: a measure of the proportion of protein loss in surgical patients. Journal of British Surgery. 1988 Sep;75(9):880-2.
30. Tanner CJ, Barakat HA, Dohm GL, Pories WJ, MacDonald KG, Cunningham PR, Swanson MS, Houmard JA. Muscle fiber type is associated with obesity and weight loss. American Journal of Physiology-Endocrinology and Metabolism. 2002 Jun 1;282(6):E1191-6.
31. Massy NM. Hand grip strengths: Age gender stratified normative data in a population-based study. BMC Res Notes 2011;4:127.

32. Ravisankar P, Udupa KA, Prakash ES. Correlation between body mass index and blood pressure indices, handgrip strength and handgrip endurance in underweight, normal weight and overweight adolescents. Indian journal of physiology and pharmacology. 2005 Oct 1;49(4):455.
33. Alahmari KA, Kakaraparthi VN, Reddy RS, Silvian PS, Ahmad I, Rengaramanujam K. Percentage difference of hand dimensions and their correlation with hand grip and pinch strength among schoolchildren in Saudi Arabia. Niger J Clin Pract. 2019 Oct 1;22(10):1356-64.

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