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Influence of Body Mass Index on Health-Related Physical Fitness in School-Going Children of North and South Mangaluru

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Abstract

Background Being underweight, overweight, or obese has a negative impact on health outcomes in adulthood. Focusing on body mass index (BMI) since childhood may improve the quality of life and well-being of an individual in future.

Objective The aim of this study was to find the correlation of low, normal, and high BMI with health-related physical fitness components of the FITNESSGRAM test battery in school-going children of North and South Mangaluru.

Materials and Methods The study analyzed 166 respondents aged 5 to 10 years from seven Dakshina Kannada Zilla Panchayat schools in Mangaluru city. The children were divided into three groups (low, normal, and high BMI) based on their World Health Organization (WHO) growth chart standards, and they were assessed for health-related physical fitness using the FITNESSGRAM test battery.

Results There was a strong positive correlation of normal, low, and high BMI with FITNESSGRAM tests such as skinfold measurements of triceps ($r = 0.903$, 0.889, and 0.913). and calf ($r = 0.881$, 0.889, and 0.900), curl-up ($r = 0.787$, 0.776, and 0.881), and 90-degree pushup ($r = 0.816$, 0.769, and 0.858). The progressive aerobic cardiovascular endurance run (PACER) had a weak positive correlation with normal BMI ($r = 0.122$), moderate positive with low BMI ($r = 0.301$), and moderate negative with high BMI ($r = -0.584$), while the trunk lift test had a moderate positive correlation with normal, low, and high BMI ($r = 0.618$, 0.640, and 0.641).

Conclusion The study concludes that there is a positive correlation between BMI and health-related physical fitness components of FITNESSGRAM in school-going children of North and South Mangaluru.

Keywords
- body mass index
- underweight
- overweight
- FITNESSGRAM test battery
- health-related physical fitness
- school-going children

Introduction

Throughout life, being underweight (low body mass index [BMI]) and overweight (high BMI) during childhood are linked to negative health outcomes.[1] Childhood and adolescence are crucial stages in an individual's life, marked by rapid growth and the transition from childhood to adulthood.[2] The United Nations Sustainable Development Goals (UN-SDG) third global goal focuses on ensuring good health and promoting well-being for all at all ages.[3] Children and

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adolescents who are underweight are more likely to get infectious illnesses and have fewer favorable results. Second, being overweight in childhood and adolescence is linked with a higher risk and earlier onset of chronic diseases such as type 2 diabetes. Third, childhood and adolescent obesity has negative psychological implications and reduces scholastic achievement.[1]

In India, from 2006 to 2021 according to the National Family Health Survey (NFHS), the prevalence of stunting declined from 47.8 to 35.5%, the prevalence of underweight declined from 42.4 to 32.1%, the prevalence of wasting was unchanged, and the prevalence of overweight increased from 1.5 to 3.45.[4] Despite significant advancements, there are still problems with nourishment, particularly among school-age children.[5]

The UN-SDG include 17 global goals and the third global goal focuses on ensuring good health and promoting well-being for all at all ages. This third global goal includes specific targets, including target 3.2, which focuses on eliminating avoidable deaths of infants and children under the age of 5 years by 2030. All nations should aspire to reduce neonatal death to 12 per 1,000 live births or below, and under-5 mortality to 25 per 1,000 live births. This target plays a major role in tackling underweight, overweight, and obesity further reducing the mortality rates in children as well as adolescents to achieve the SDG goals.[3,6]

The BMI is a widely used indicator of weight status, which ranges from extreme thinness to obesity. For children and adolescents, BMI is categorized as the following: more than 2 standard deviations (SD) below the median of the World Health Organization (WHO) growth reference for children and adolescents (hereafter referred to as moderate and severe underweight), 2 SD to more than 1 SD below the median (mild underweight), 1 SD below the median to 1 SD above the median (healthy weight), more than 1 SD to 2 SD above the median (overweight but not obese), and more than 2 SD above the median (obesity). The WHO definitions were used because they include a comprehensive set of BMI categories ranging from moderate and severe underweight to obesity.[1]

A person's potential to engage in physical fitness, involving aerobic capacity, endurance, strength, or flexibility, is crucial for health in both childhood and adulthood. Low fitness levels during childhood and adolescence increase the risk of obesity, cardiovascular disease, skeletal health deterioration, lowered quality of life, and poor mental health.[7] The American College of Sports Medicine's states that children's health/fitness evaluations can also take place outside of a clinical setting. The components of health-related fitness can be evaluated using the FITNESSGRAM test battery, which includes components such as body composition (measured by BMI, skinfold measurements), cardiorespiratory fitness (CRF; measured by a progressive aerobic cardiovascular endurance run [PACER]), and muscular fitness (measured by the curl-up test, trunk lift test, and 90-degreee pushup test).[8,9]

The objective of the present study was to investigate the correlation between BMI and health-related physical fitness in school-going children in Mangaluru city, Karnataka, India. As children with low BMI (underweight) are prone to malnutrition or undernutrition resulting in infectious illness like Covid-19 because of lack of access to community-based nutrition services that would support their treatment. Conversely, children with high BMI (overweight) are said to acquire noncommunicable diseases easily such as type 2 diabetes, cardiovascular diseases, and cancers. The chance of developing one of these noncommunicable diseases as an adult increases with an increase in BMI during childhood and adolescence. Adverse psychosocial effects of childhood obesity, stunting, and wasting include reduced self-worth, mental health, academic performance, social engagement, and quality of life.[6,10–12]

This study focuses on children with low and high BMI, and uses FITNESSGRAM to find the average values for these physical fitness factors. Previous studies have shown that children with high and low BMI have varying levels of physical fitness, but the need of this study focuses on school-going children specially of North and South Mangaluru and evaluate their physical fitness levels as physical fitness has not been correlated with BMI.

Methodology

The ethical clearance for the proposed study was acquired from Nitte Institute of Physiotherapy's Institutional Ethics Committee, Mangaluru, Karnataka, India, with Ref: NIPT/IEC/Min//19/2022–2023/, dated February 9, 2023. The trial was approved to be conducted at seven Dakshina Kannada Zilla Panchayat (DKZP) higher primary school from South and North Mangaluru, Karnataka. The list of schools was obtained from DKZP, following which schools were selected randomly using Random.org Web site's random sequence generator, and permission from the school principals was taken to conduct the study in the selected seven schools. After approval from the institutional ethics committee, the trial was prospectively registered in the Clinical Trial Registry – India with the registration number CTRI/2023/03/050957. The study was performed from March 2023 to March 2024.

Inclusion criteria: School-going children aged between 5 and 10 years, both males and females; school-going children with low, normal, and high BMI; BMI of the children assessed on the basis of the WHO growth standards; and children with understanding of Kannada, English language, and located within south and north Mangaluru from the priorly selected schools were included.

Exclusion criteria: Children already diagnosed with any kind of cardiovascular disorders; children who have reported dizziness; and children with difficulty in standing due to ankle, knee pain, or injury, any fractures of the upper and lower limb were excluded.

Sample size calculation: It was calculated using the formula $n = Z1-\alpha/22 \times P(1-P)/d^2$; $Z1-\alpha/2 = 1.96$, where $d =$ absolute precision. The sample size was determined as 166 and it was randomly divided between seven schools on the basis of the number of students available in each school.

Demographic data were gathered and participants were evaluated to determine if they met the inclusion criteria from the schools that had granted permission for the study prior to recruitment. Informed consent was obtained from the participants who satisfied the inclusion criteria. The children's details were entered into the data screening tool, which was then used to screen the children's BMI based on the WHO growth standards. These standards include BMI for age, height for age, and weight for age. Following the screening, the children were classified into three groups: low BMI, normal BMI, and high BMI. After the children underwent assessment for health-related physical fitness using the FITNESSGRAM test battery, the data collection form was filled with obtained results, following which the average values for the children were determined based on their BMI. Subsequently, a statistical analysis was performed using all the information gathered during the study.

Statistical Analysis

Statistical analysis of the data was performed using the SPSS software version 29.0.10 (SPSS Inc.; Chicago, IL). Collected data were summarized by using the descriptive statistics: frequency, percentage; mean and standard deviation (SD). The independent sample "*t*" test was used to compare age, BMI, and various components of the FITNESSGRAM test according to gender as well as shoulder stretch. To find the relation between age, BMI, and the various components of FITNESGRAM test battery, the Pearson correlation coefficient ("*r*") was used. A *p* value less than 0.05 was considered statistically significant.

Results

The study consisted of a total of 166 school-going children. Among the 166 children, 76 (45.8%) were males and 90 (54.2%) were females. The children were divided according to their age groups as follows: 26 (15.7%) children were of 5 years of age, 26 (15.7%) children were of 6 years of age, 26 (15.7%) children were of 7 years of age, 30 (18.1%) children were of 8 years of age, 28 (16.9%) children were of 9 years of age, and 30 (18.1%) children were of 10 years of age. The distribution of children according to BMI was as follows: normal BMI, 66 (39.8%); low BMI, 61 (36.7%); and high BMI, 39 (23.5%; ►**Table 1**).

The correlational analysis of the study showed that there was a strong positive correlation of normal, low, and high BMI with FITNESSGRAM tests such as skinfold measurements of triceps ($r = 0.903$, 0.889, 0.913), calf ($r = 0.881$, 0.889, 0.900), curl-up ($r = 0.787$, 0.776, 0.881), and 90-degree pushup ($r = 0.816$, 0.769, 0.858). The PACER had a weak positive correlation with normal BMI ($r = 0.122$), moderate positive correlation with low BMI ($r = 0.301$), and moderate negative correlation with high BMI ($r = -0.584$). The trunk lift test had a moderate positive correlation with normal, low, and high BMI ($r = 0.618$, 0.640, 0.641; ►**Tables 2–4**).

Discussion

The objective of the current study was to determine the correlation between school-age children's BMI and their health-related physical fitness components. Results showed a strong positive correlation between normal, low, and high BMI and FITNESSGRAM components, while PACER had a weak positive correlation with normal BMI, moderate positive correlation with low BMI, moderate negative correlation with high BMI, and a moderate positive correlation with trunk lift test.

According to the study conducted by Ma'arif et al in 2023, BMI calculation, physical activity questionnaire for older children (PAQ-C), and 20-m multistage fitness test were used to assess physical fitness to determine the relationship between different variables. The findings revealed a positive correlation between BMI and physical activity.[13] The present study explores health-related physical fitness in children aged 5 to 10 years, examining the correlation between BMI

Table 1 Correlation between low BMI and the various components of FITNESSGRAM test battery

N = 166		Frequency	%
Gender	Male	76	45.8
	Female	90	54.2
Age groups	5 y	26	15.7
	6 y	26	15.7
	7 y	26	15.7
	8 y	30	18.1
	9 y	28	16.9
	10 y	30	18.1
BMI	Normal BMI	66	39.8
	Low BMI	61	36.7
	High BMI	39	23.5

Abbreviation: BMI, body mass index.

Table 2 Showing correlation between low body mass index (BMI) and the various components of FITNESSGRAM test battery

FITNESSGRAM test battery	Low BMI (kg/m^2)	
	"*r*"	*p* value
Aerobic capacity (the pacer in laps)	0.301	0.368
Triceps (%)	0.889	0.001[a]
Calf (%)	0.850	0.001[a]
Curl-up in 1 min (no. completed)	0.776	0.001[a]
Trunk lift (inches)	0.640	0.001[a]
90-degree pushup in 1 min (no. completed)	0.769	0.001[a]

Note: "*r*" = Pearson's correlation coefficient.
[a]Significant.

Table 3 Correlation between normal body mass index (BMI) and the various components of FITNESSGRAM test battery

FITNESSGRAM test battery	Normal BMI (kg/m^2)	
	"*r*"	*p* value
Aerobic capacity (the pacer in laps)	0.122	0.705
Triceps (%)	0.903	0.001[a]
Calf (%)	0.881	0.001[a]
Curl-up in 1 min (no. completed)	0.787	0.001[a]
Trunk lift (inches)	0.618	0.001[a]
90-degree pushup in 1 min (no. completed)	0.816	0.001[a]

Note: "*r*" = Pearson's correlation coefficient.
[a]Significant.

Table 4 Correlation between high body mass index (BMI) and the various components of FITNESSGRAM test battery

FITNESSGRAM test battery	High BMI (kg/m^2)	
	"*r*"	*p* value
Aerobic capacity (the pacer in laps)	−0.584	0.169
Triceps (%)	0.913	0.001[a]
Calf (%)	0.900	0.001[a]
Curl-up in 1 min (no. completed)	0.881	0.001[a]
Trunk lift (inches)	0.641	0.001[a]
90-degree pushup in 1 min (no. completed)	0.858	0.001[a]

Note: "*r*" = Pearson's correlation coefficient.
[a]Significant.

and various components of the FITNESSGRAM test battery, which also revealed a strong positive correlation between the components. The study conducted by Neshteruk et al in 2023 included 917,554 youth from 4th to 12th grade whose fitness was evaluated using FITNESSGRAM tests. The findings of this study and the present study stated that children who were heavier had poorer physical fitness levels when compared with children with normal weight status.[14]

Manzano-Carrasco et al conducted a study in 2023 that included 2,256 children aged 5 to 18 years whose anthropometric measurements were evaluated and whose physical fitness was assessed. The study concluded that children with normal BMI had better levels of physical fitness than children who were obese and underweight.[15] The current correlational investigation revealed a strong positive correlation between triceps and calf muscle measurements, curl-up tests, and pushups in school-age children with normal BMI. However, aerobic capacity and trunk lift tests showed modest positive associations. This helps understand how a child's BMI affects their physical fitness and affects them as obese or overweight adults.

Similar studies conducted by Chen et al[16] and Verbecque et al[17] in 2022 that included in total 18,209 children aged 5 to 12 years and 7 to 18 years, respectively, BMI was calculated and classified into different levels, and the physical fitness of the children was assessed using different tests and Performance and Fitness (PERF-FIT) battery. These studies concluded that children with BMI levels above or below the standard range have an inferior physical fitness than those with normal BMI. The current study's findings are consistent with those of the two studies, which found that poor levels of physical fitness are closely related to children's BMI levels.

Xu et al[18] in 2020 and Lopes et al in 2019[19] found that children with normal BMI have better levels of physical fitness. In contrast, the present study categorized children into three BMI groups (normal, high, and low) and assessed their physical fitness using the FITNESSGRAM test. Normal children performed better in all fitness components, while low BMI children excelled in trunk extensor strength, flexibility, and shoulder stretch tests. High BMI children had better abdominal and upper body strength and endurance.

Adhvaryu and Ghate conducted a study in Pune in 2019 with 235 children aged 8 to 11 years whose BMI was determined and physical fitness was assessed using the President's fitness challenge. The study found the fundamental levels of physical fitness in school-aged children to be low.[20] In contrast, the current study revealed a strong positive correlation between high, low, and normal BMI in various physical tests, including triceps and calf skinfold measurements, curl-up tests, and 90-degree pushups. However, the trunk lift test has a moderately positive association, while aerobic capacity has a weak positive correlation. This highlights the importance of BMI and health-related physical fitness for a healthy adult life and improved quality of life in future as childhood physical fitness directly impacts on the health outcomes as an older individual.

The merits of the study were that it highlights the importance of both BMI and health-related physical fitness in school-going children as it plays a major impact on individual health as these children grow older. One of the demerits was that the study was limited to seven schools in Dakshina Kannada due to time constraints. More schools may have been added to provide more comprehensive and generalized data.

It has been noted that during the implementation of FITNESSGRAM test battery in schools, no adverse effects or injuries were observed in the children. Also, a positive attitude among school principals and teachers were noted toward the study.

Conclusion

The results of the present study show that there is a positive correlation between BMI and health-related physical fitness components (FITNESSGRAM Test Battery) in school-going children. This research reveals that school-going children age 5 to 10 years with normal BMI exhibit superior performance

in all aspects of health-related physical fitness components compared with those with low and high BMI.

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Conflict of Interest
None declared.

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