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Body Mass Index Affects Physical Fitness, Academic Performance and Executive Functions in School Going Children - A Correlation Study

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ABSTRACT

Background: Prevalence of obesity among 5- to 19-year-old Indian children, is 3.6 and 11.7%. Being an obese child increases the likelihood of being an obese adult and there by leading to obesity related complications. School going children are in an important age of cognitive and motor development. So, the study mainly aimed to find the correlation of physical fitness, executive functions and academic performance with body mass index in school going children.
Methodology: This cross-sectional study was performed with 120 children with age group of 9 to 13 years. Height, weight, BMI was taken. 20 metre multistage fitness test was performed for physical fitness, trial making test for executive functions and academic performance scale for academic performance were taken.
Results: Data was analysed using Spearman correlation coefficient which showed that BMI had positive corelation with physical fitness and executive functions p value (<0.01) and not with academic performance.
Conclusion: Thus, result shows that good physical fitness is very important for better physical and mental growth especially for obese children and schools should include the fitness testing and physical activities as guided by the expert physiotherapist as the part of curriculum and simultaneously parental awareness for physical exercises should also be done to prevent their child form serious complications of obesity.

Keywords: Academic performance, Body mass index, Executive functions, Obesity

INTRODUCTION

Fitness is a general term used to describe the ability to perform physical work. It includes following components: Health related components like cardiorespiratory endurance, Muscular endurance, Muscular Strength, Flexibility, Body composition and Skill Related components like Agility, Balance, Coordination, Power, Speed. Obesity is defined as an abnormal and/or excessive accumulation of fat that can impair health.(1)Childhood obesity has become the major global health problem. Severity and prevalence of childhood obesity has significantly increased over the past three decades. Being an obese child increases the likelihood of being an obese adult and there by leading to obesity related complications like increased risk of developing the metabolic syndrome, cardiovascular disease, type 2 diabetes, non-alcoholic fatty liver disease, obstructive sleep apnea, polycystic ovarian syndrome, asthma, orthopaedic complications, psychiatric disease, etc.,(2) . The factors influencing childhood obesity are physical inactivity , sedentary behaviour , dietary habits , socio-economic status , sleep

duration and intensity , obesogenic environment and marketing strategies for energy-densed foods. (3)

According to the recent research by Centres for Disease Control and Prevention (CDC) 2017 to 2022 the childhood obesity has increased by age: Among children with 2 to 5 years of age 12.7% were obese, 6 to 7 years of age 20.7% were obese, and with 12 to 19 years of age 22.7 % were obese and boys having more obesity than girls. By 2030, The World Obesity Federation predicts the number of school aged children and adolescents with obesity will rise from 150 million worldwide to over 250 million. This increase will place a significant burden on healthcare and social services with the aging in population .(4)

Intake and metabolism of food are regulated by different hormones, such as leptin, whose circulating levels are often altered in obesity. Leptin normally acts to inhibit neuropeptide Y, a neurohormone present in the gut and hypothalamus, to suppress the appetite. Obesity can affect the cellular integrity of the BBB (independent of the transporters), which can further affect the satiety control at the level of the central nervous system. Adiponectin is an adipokine derived from plasma protein and levels of adiponectin messenger RNA (mRNA) levels are reduced in adipose tissue in obesity. A further extension of this gut-brain axis reveals the role of ghrelin, a hormone produced locally in the stomach which has receptors in hypothalamus and pituitary. It acts to stimulate the appetite by stimulating the release of neuropeptide Y in the brain. (5).According to Madhavi Bhargava et.al, there was a significant association between the lack of physical activity and overweight and obesity and unstructured leisure time which encourages physical activity and recreation during or after school should be given equal emphasis as academics.(6)

Academic stress (AS) is a serious issue. According to Karel Frömel et.al, the overall low physical activity of adolescents during recesses and after school highlights the need to compensate for AS by adequate physical activity. This more apparently is applied for adolescents with recurrent AS in several consecutive lessons. Academic stress can be considered in line with Selye's understanding of this term as an individual's nonspecific set of responses to internal or external stimuli intervening with the habitual academic process. (7) . According to John R. Best, et.al , combination of moderate to vigorous physical exercise and cognitively demanding activities, which applies especially to the practice of sports, will have a greater effect on executive functioning.(8) Thus , on the basis above mentioned results of the studies and lack of literature , there is a strong need to find the correlation of the BMI with various parameters in school going children and so the aim of the study is to find corelation of BMI with physical fitness , academic performance and executive functions in school going children.

MATERIALS AND METHODS

The study was an observational cross-sectional study conducted in 2023. Data were collected from school going children aged 9- to 13-year-old. A total of 120 subjects were included according to the inclusion and exclusion criteria. Both male and female subjects were included and subjects with any neurological problem, chronic illness or musculoskeletal problems , any recent injuries were excluded.(1) Written Consent form was signed by the parents of the subjects after explaining them the procedure to be done.

Procedure:

BMI: Age of a subject was determined using the date of birth in school register. A prior written consent was taken from parents, and verbal assent was taken from the children after detailed explanation. Weight was recorded using the digital weighing machine (Omron Model: HN286, accuracy 0.1 kg) and height was measured using a wall-mounted staturemeter (Seca body meter 206, accuracy 0.001 m). Both height and weight

were taken using the standard measures recommended by the World Health Organization (WHO)(9)

20m Shuttle run test: The physical fitness was assessed using 20-meter Shuttle run test(20mSRT). The 20mSRT was administered as described by Leger et al (Leger, Mercier, Gadoury, & Lambert, 1988). Participants jogged or ran in a straight line between two lines 20 m apart while keeping pace with pre-recorded audio signals. The initial speed was 8.5 km/hour and increased by 0.5 km/hour each minute. The test was terminated if the participant failed to reach the end lines in time with the audio signals on two consecutive occasions or when the subject stopped because of self-reported fatigue. Results were recorded to the nearest stage (minute) completed. The equation of Leger et al. (1988) was used to estimate the V_O2peak. To calculate the V_O2peak from the result of the 20 m shuttle run test score, age (A; in years), and the final speed (S; running speed at the last completed level (kmh21) 5 8 1 0.5 per stage number, in kmh21) were entered into the following formula (r 5 0.7; for children and adolescents, from 819 years) V_O2peak (ml kg21 min21) 5 31.025 1 3.238 x S 3.248 x A 1 0.1536 3 S 3 A. Intra-rater reliability was assessed by determining the intraclass correlation coefficient (ICC 5 0.96, CI 95% 0.95 to 0.97).(10)

Academic Performance: The Academic performance was measured using academic performance rating scale. The Academic Performance Rating Scale (APRS) is a 19-item scale, where teachers rate the child's academic abilities and behaviours in the classroom on a 5-point scale. Higher scores indicate greater classroom academic performance(11). APRS is highly reliable rating scale.(12)

Executive functions: Executive functions of the subjects were assessed using Trial making test. The Trail Making Test (TMT) has two parts and the times taken to complete each part were used to measure central executive functioning. In Part A (TMT-A), the subjects had to draw a line to connect consecutive numbers, from 1 to 25. In Part B (TMT-B), the subjects had to connect numbers and letters in an alternating progressive sequence, 1 to A, A to 2, 2 to B, and so on. In order to measure central executive functioning, the difference in time taken to complete TMT-B, which stresses central executive processes of task-set inhibition, cognitive flexibility, and the ability to maintain a response set, and the time to complete TMT-A, which has little executive input, was calculated. (13) Retest reliability of TMT-A was between 0.76 and 0.89 and TMT-B was 0.86 to 0.94.(14)

STASTICAL ANALYSIS

The statistical analysis was done using SPSS software version 26. The normality of the data was checked using Kolmogorov-Smirnov and data did not follow the normal distribution, so Spearman Corelation coefficient was used to find the corelation of BMI with physical fitness, BMI with academic performance, BMI with executive functions.

RESULTS

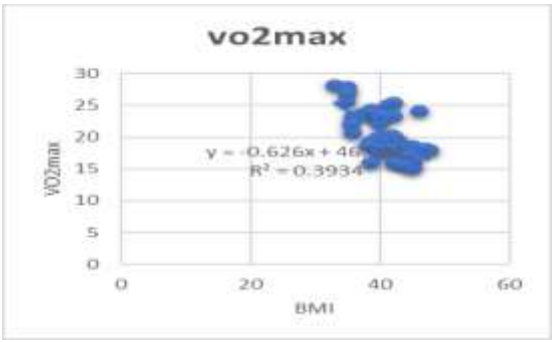
The results were derived from the analysis of data of 120 subjects. The mean and standard deviation of variables are given in table 1.1. The results suggest that physical fitness has a negative correlation with BMI which means that as the BMI increases the physical fitness reduces shown in graph 1.1. The academic performance is not affected or altered by BMI as shown in graph 1.2 So there is no correlation of BMI with

academic performance. The executive functions of the children are affected by BMI as there is a positive corelation of trial making test and BMI as shown in graph 1.3. So the children with the higher BMI would have lower level of executive functions or broader term lower cognition level.

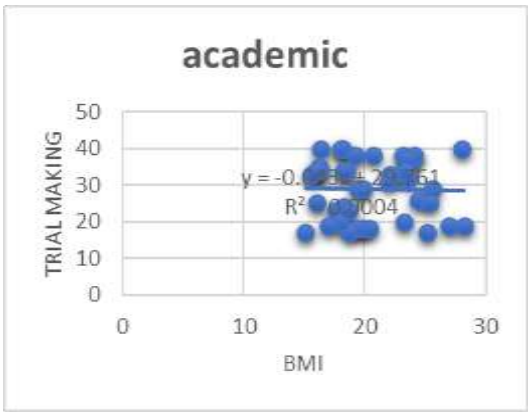
Table 1.1

VARIABLE	MEAN	STANDARD DEVIATION
VO2 Max	39.84	3.47
BMI	20.60	3.66
Trial Making Test	43.05	11.84
Academic Performance Scale	28.8	8.06

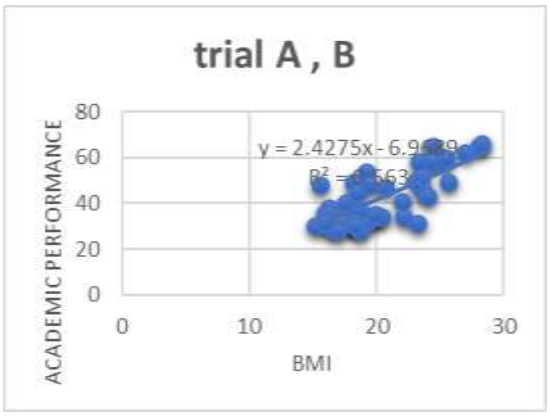
Table 1.1



Graph 1.1 p<0.01, r = -0.71



Graph 1.2 p<0.01, r = -0.03



Graph 1.3 p<0.01, r = .0.66

DISCUSSION

According to the results of the study the BMI has the strong negative correlation of BMI with physical fitness and positive correlation with executive functions and no corelation with academic performance. VO2max represents the physical fitness of an individual. The reason behind the corelation of BMI and physical fitness is in obese individuals, there is increase in Type II muscle fibres and decrease in type I muscle fibres which may have effect on reduced oxygen uptake. Furthermore, there may be changes in the cardiovascular functions in severely overweight individuals. Greater the BMI, the functional impairment will be more severe. So, our study results correlate with this study done by Sunita Basavaraj Kalyanshetti et.al, which concluded that Increase in the BMI affects the physical fitness and causes decrease in the VO2 max. There is a negative association between BMI and VO2 max.(15) Another study by Madhavi Bhargava et.al, also supported the result of our study that significant association between the lack of physical activity and overweight and obesity in school-going children. There is a need to enhance physical activity, sports, and recreational opportunities at school as well as home to prevent overweight and obesity in children. These will be important primary prevention measures to combat the epidemic of noncommunicable diseases . (6)

Primary goal of schools is student academic achievement. Academic outcomes have become even more important. As administrators have increased the focus on academic achievement since then, schools increasingly have eliminated Physical Activity opportunities. Government

agencies have conducted reviews on PA and academic achievement that have potential policy implications. The Centers for Disease Control and Prevention (CDC) reviewed the literature on PA during the school day and academic achievement. The CDC review concluded that PA may have a positive effect or no effect on academic performance. Additionally, the PA Guidelines Advisory Committee reviewed literature on the health benefits of PA for children and youth, including the mental health benefits.1 In its report, the Committee concluded, "Although observational studies have found relationships between physical fitness and grades and test scores, those between PA and direct measures of academic achievement often have had null findings."(16) . Our study results states that BMI has no correlation with academic performance. A study by Erin K. Howie et.al, stated that Researchers have made considerable progress in examining Physical activity and academics in the past 5 years, yet results are still inconsistent. The reason or mechanism behind this still remains unclear. Another study by Keyun Xu et.al, did a research on Predicting academic performance associated with physical fitness of primary school students using machine learning methods and concluded that The body mass index, muscle strength, and aerobic endurance of primary school students are significantly different between academic performance groups and are correlated with their academic performance. Machine learning methods can help effectively predict academic performance associated with the physical fitness of primary school students.(17) However it does not support to the result of our study.

Knowledge of the benefits of PA on executive functioning has become widespread in recent years, though research support for this relationship has been amassing for decades.(18)The development of executive function is linked to maturation of prefrontal cortex (PFC) in childhood. Childhood obesity has been associated with changes in brain structure, particularly in PFC, as well as deficits in executive functions. Kathryn P King et.al, was studying about the corelation of Inflammation, Executive Function, and Adiposity in obese Children and found Positive associations were identified between adiposity and inflammation and negative to null associations were identified between inflammation and executive functions and indirect effects of adiposity on executive functions through inflammation were noted(19) . More generally, children with lower levels of executive abilities are more likely to be sedentary and have higher rates of snack consumption, and are less likely to benefit from weight-loss interventions. The role of executive function in planning and decision-making, response inhibition, and reward evaluation influences food intake, contributing to increased BMI. functional magnetic resonance imaging studies have demonstrated that the dorsolateral prefrontal cortex (DPFC) is differentially activated in obesity in both adults and children. This region is critical to cognitive control over eating. Physiologically, regular Physical activity has been shown to increase Brain-Derived Neurotrophic Factor (BDNF) and hippocampal neurogenesis to improve brain function. Neuroelectric measures have shown improved cognitive control and attention in children after acute and chronic Physical activity.(16) So according to Lisa Ronan et.al, childhood obesity is associated with compromised executive function. This relationship may be partly explained by BMI-associated reduced cortical thickness in the PFC which is in support to the result of this study.(20)

The limitation of the study is various components of executive functions were not analysed separately and that academic performance was measured using teacher rated scale. In future the studies focusing on the individual components of executive functions can be done and also other methods of measuring academic performance can be considered where

review of parents along with teacher should also be considered and also intelligent quotient component can be added.

CONCLUSION

Thus, the study concludes that BMI affects the physical fitness and executive performance of the school going children which are the required aspects of the child in that particular age and awareness about the childhood obesity and its prevention should be made to cope up with this pandemic of childhood obesity.

Declaration by Authors

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