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RESEARCH ARTICLE

The Relationship Between Weight Status, Vital Signs and Physical Fitness in Children with Simple Obesity: A Cross-Sectional Observational Study

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Abstract
Background: Obesity is considered to impact physical fitness in children. There is scarce data on indices of physical fitness in Indian children with simple obesity We aimed to determine the effects of weight status on indices of physical fitness in North Indian children with simple obesity. **Methods:** Vital parameters such as blood pressure, pulse rate, respiratory rate, and rate of perceived exertionwere measured before and after the six-minute walk test (6MWT) in obese children (BMI ≥95th percentile) (Group 2, n=70) aged 5-15 years and were compared to non-obese children (BMI 25th to 75th percentile) (Group 1, n=70). President's Challenge Fitness test was used to measure the physical fitness of each subject. **Results:** The mean age, weight and BMI of children in Group 1 and Group 2 were 9.07±2.88 and 8.93±3.13, 27.42±12.08 and 48.87±17.89 and 16.54±4.26 and 27.30±5.2, respectively. The mean blood pressure recorded before 6MWT was similar in the two groups but pulse rate, respiratory rate, and BORG scale values were higher in Group 2. Children in Group 2 also showed significant elevation of vital parameters compared to Group 1 after the 6MWT. Additionally, children in Group 2 performed poorly in all the physical fitness parameters compared to those in Group 1 following the President's Challenge Fitness test. **Conclusions:** Children with obesity showed several alterations in vital parameters and indices of physical fitness. Further studies are required to access the effect of interventions aimed at improving the physical fitness in children with obesity.

Keywords
Childhood obesity, Body mass index, Physical fitness, Vital parameters, 6-minute walk test.

INTRODUCTION

Obesity is described as a body weight greater than a person's average or standard weight for their height and age and is evaluated in clinical practice by the body-mass index (BMI) (Johnston et al., 2022) . The prevalence of pediatric obesity has significantly increased in the past few decades (Ogden et al., 2014). At the same time the physical fitness of children and adolescents has deteriorated (Malina 2007) . The increased prevalence is related to several factors that include genetics, environmental factors, energy intake and expenditure. (Blüher, 2019).

Obesity in childhood raises the likelihood of obesity during adolescence and adulthood (Reinehr ,2018). It is linked to several co-morbid conditions such as cardiovascular disease, gallbladder disease, osteoarthritis, hypertension, dyslipidemia, sleep apnea, type 2 diabetes, and thyroid dysfunction (Koliaki et al., 2019; Pogorelic et al., 2019; Pacca et al., 2018; Dayal et al., 2014; Jehanet et al., 2018; Yadav et al., 2018 ; Dayal and Kumar 2019). Maintaining physical fitness holds its

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significant place in obesity prevention.(Chen et al., 2020).The most effective prevention strategies include therapeutic lifestyle modifications, maintaining high levels of physical activity, and maintaining a healthy weight (Johnston et al., 2022).

The BMI cut-off for obesity is ≥30 kg/m2 in the Western populations whereas in Asian populations it is considered to be ≥25.0 kg/m2 (Singh et al., 2008). As compared to Caucasians, Asians have higher body fat percentage for a given BMI and the health risks related to obesity also occur at lower BMI (Goda and Masuyama, 2016; Singh et al., 2008). Prevention of obesity is therefore important during childhood to avoid metabolic complications and the related morbidity during adulthood.

Over the past few years, researches have focused on the relationship between obesity and physical fitness. Although several researches have linked BMI to blood pressure and physical fitness.(Chen et al., 2020; Bi C et al., 2019; Köchli et al., 2019; Dumith et al., 2010; Farah et al., 2018; Palmeira et al., 2017; Rodríguez-Colón et al., 2011) few have looked at the effect of BMI on respiratory rate and pulse rate, in children.(Farah et al., 2018; Dixon et al., 2018)

One of the studies assessed vital respiratory parameters (forced expiratory volume in 1 s , forced vital capacity ,the peak expiratory flow and forced expiratory volume) in obese adolescents but didn't focus on the subjective assessment of respiratory parameters (Dixon et al., 2018) Kochli S. et al. correlated obesity and hypertension but measurements were confined to resting state not after exertion.(Kochli et al., 2019) Another study by Mohan B. et al. also worked on hypertension in obese children but age group included was above 11 years and blood pressure measurements after exertion/activity were not taken into consideration.(Mohan et al., 2004) On contrary this study assesses vital parameters of children between 5-15 years of age at rest as well as on exertion. Physical fitness decline with increased BMI was concluded by many studies. None of them used all the components of presidents fitness challenge test as a reflection of physical fitness.(Chen et al., 2020; Bi et al., 2019; Dumith et al., 2010; Farah et al., 2018; Palmeira et al., 2017;) In this study we focused on physical fitness as a whole and included all the components of president's fitness challenge test. Studies focusing on combined relationship between vital parameters and physical fitness in obese children are very scarce. So, this study aimed to determine cross-sectional relationship between obesity, physical fitness, and vital indicators in Indian children, as well as to compare them to normal weighed children. Additionally, there is limited data on physical fitness in Indian children who are at a raised risk for obesity-related metabolic problems at lower BMI than their Western counterparts. We thus planned to study physical fitness in children with simple obesity by assessing a range of parameters including all components of the President's Challenge Fitness test.

METHODS

This cross-sectional study, conducted between October 2021 and March 2022, aimed to assess the fitness profile and vital parameters of obese children as compared with non-obese children. Purposive sampling was used to identify participants for the study, which included children between the ages of 5 and 15 years enrolled in tertiary care hospital's outpatient clinic. Sample size calculation was done using a formula given below (Charan and Biswas, 2013) .

$$Z_{1-\alpha/2}{}^2 \, P \, (1-p) \, / d^2$$

$$Z1-a/2 = 1.96 \text{ at } P<0.05$$

d = 8% Absolute error or precision as per previous study (Dumith et al. 2010).

Sample size calculations indicated that a sample of 114 would provide over 80% power at a 5% significance level to detect an 8% absolute error or precision among groups. This was based on the difference observed in the previous study (Dumith et al. 2010) . The study protocol was approved by the Institute Ethics Committee (INT/IEC/2021/SPI-1550) on 25th October 2021. Prior to the inclusion of the children in the study, informed consent from parents and assent from the children was obtained. All children underwent weight and height measurements to calculate BMI. Children with simple obesity, defined as BMI ≥95th percentile on standard Indian growth charts were recruited as cases (Group 2) whereas near age-matched children with BMI between 25th to 75th percentiles were recruited as controls (Group 1) (Khadilkar et al. 2012). Children with any congenital, structural abnormalities, physical or mental developmental disorders, endocrinopathies,

and any systemic illness were excluded from the study.

Vital parameters such as blood pressure, pulse rate, respiratory rate, and rate of perceived exertion were measured before and after the Six-Minute Walk Test (6MWT). Sphygmomanometer was used to measure blood pressure in upright position and classified according to a previous study (Krishna 2006).The examiner observed the rise and fall of the abdomen to determine the respiratory rate. The rate of breathing was measured for 30 seconds and then multiplied by two. By placing the finger on the radial artery and counting the pulsations, the pulse rate was determined. The rate was calculated by counting the pulse for 30 seconds and multiplyingthe result by two. The 6MWT was carried out according to a set of guidelines (Fell et al. 2021). The individuals were asked to rate their perceived exertion level before beginning the 6MWT. The subjects were then told to walk up and down a measured hallway for six minutes, covering as much ground as possible in this 6-minute timeline. The test is self-paced, so the participants could take a break if they choose, but the clock kept ticking. At the end of the test, the distance walked, the Borg scale measured by rate of perceived exertion, the pulse rate, respiratory rate, and blood pressure was recorded (Del Corral et al. 2022).

The President's Fitness Challenge test evaluates aerobic capacity, strength, and flexibility (Hale and Franks, 2001).It's components include Shuttle run testing forleg strength/power/agility, V-sit testing for lower back/hamstring flexibility**,** Curl-up or partial curl-ups forabdominal strength/endurance, pull-ups or right angle pushups for upper body strength/endurance, and one-mile walk/run for heart/lung endurance.

One mile walk test evaluated the shortest possible time for completing one mile walk. Shuttle test time was measured as the fastest time to complete two shuttles between 30 feet distant parallel lines. Correctly performed curl-ups in one minute were noted. Sit and reach test distance was measured in sitting position with legs shoulder width apart. The distance from the measuring line was recorded in centimeters. Right angle pushups were measured as maximum number of pushups a child could perform without exhaustion.

Statistical analysis

Statistical Package for the Social Sciences (SPSS version 26.0 Armonk, NY: IBM Corp) was used to analyze the data. Descriptive statistics with means, SDs, and percentages to record baseline demographics and clinical characteristics were tabulated. The Shapiro-Wilk test was used to analyze data normality, and parametric tests were used based on the findings. The t-test and independent t-test were used for within-groups and between-groups analyses. A significance level of 5% was used for all data analysis.

RESULTS

One hundred and forty children, 70 in each group, were recruited into the study. Their demographic characteristics are shown in Table 1.

Table 1: Demographic characteristics of subjects in the two groups.

Variable		Group 1 (n=70) Mean (SD)	Group 2 (n=70) Mean (SD)	P-value
Age (yr)		9.0 (2.8)	8.9 (3.1)	0.77
Weight (Kg)		27.4 (12.0)	48.8 (17.8)	<0.001
Height (cm)		127.7 (21.4)	133.1 (14.7)	0.08
BMI (Kg/m^2)		16.5 (4.2)	27.3 (5.2)	<0.001
BMI percentile		42.5 (34.3)	95.0 (0.0)	<0.001
Sex	Boys	41 (58.6%)	44 (62.9%)	<0.001
	Girls	29 (41.4%)	26 (37.1%)	<0.001

Vital parameters before and after 6MWT

The SBP and DBP recorded before 6MWT were similar in the two groups (p-values 0.08 and 0.32, respectively). In contrast, there were significant differences between the cases and controls in pulse rate, respiratory rate, and rate of perceived exertion recorded before the 6MWT (p-value <0.001) (Table 2).

The two groups also showed significant differences in all the vital parameters recorded after the 6MWT, i.e., Group 2 showed significant elevation of vital parameters compared to Group 1 (P<0.001) (Table 3).

Table 2: Change in vital parameters within the study groups after the 6-minute walk test

Group	Parameter	Before test	After test	P value
Group 1 (n=70)	Systolic BP	106.5 (6.0)	112.9 (5.4)	<0.001
	Diastolic BP	70.4 (3.6)	74.4 (3.9)	<0.001
	Pulse rate	70.3 (3.6)	77.1 (3.4)	<0.001
	Respiratory rate	17.4 (2.3)	20.4 (2.1)	<0.001
	ROPE	0.0 (0.0)	0.3 (0.3)	<0.001
Group 2 (n=70)	Systolic BP	108.6 (7.8)	123.5 (7.2)	<0.001
	Diastolic BP	69.6 (5.7)	79.1 (5.3)	<0.001
	Pulse rate	75.0 (5.5)	93.2 (12.0)	<0.001
	Respiratory rate	21.2 (13.2)	26.5 (2.6)	0.0018
	ROPE	0.1 (0.2)	3.2 (1.4)	<0.001

Abbreviations: BP, blood pressure; ROPE, rate of perceived exertion

Table 3: Comparison of the studied vital parameters before and after the 6-minute walk test between the two groups

Parameter	Timing	Group 1 (n=70) Mean (SD)	Group 2 (n=70) (Mean (SD)	Mean change	P value
Systolic BP (mm Hg)	Before	106.5 (6.0)	108.6 (7.8)	2.0	0.08
	After	112.9 (5.4)	123.5 (7.2)	10.6	<0.001
Diastolic BP (mm Hg)	Before	70.4 (3.6)	69.6 (5.7)	0.8	0.32
	After	74.4 (3.9)	79.1 (5.3)	4.7	<0.001
Pulse rate (per minute)	Before	70.3 (3.6)	75.0 (5.5)	4.7	<0.001
	After	77.1 (3.4)	93.2 (12.0)	16.1	<0.001
Respiratory rate (per minute)	Before	17.4 (2.3)	21.2 (13.2)	3.7	0.02
	After	20.4 (2.1)	26.5 (2.6)	6.1	<0.001
ROPE	Before	0.0 (0.0)	0.1 (0.2)	0.1	<0.001
	After	0.3 (0.3)	3.2 (1.1)	2.8	<0.001

Abbreviations: BP, blood pressure; ROPE, rate of perceived exertion

Physical fitness parameters

Children in Group 2 performed poorly in all the physical fitness parameters compared to those in Group 1 following the President's Challenge Fitness test (P<0.001) (Table 4).

Table 4: Comparison of fitness parameters between the two study groups during the President's Challenge Fitness Test

Parameter	Group 1 (n=70) Mean (SD)	Group 2 (n=70) (Mean (SD)	Mean change	P value
Curl-ups (Reps per minute)	19.9 (2.6)	7.5 (2.3)	12.3	<0.001
Shuttle run test (Seconds)	11.7 (1.2)	19.8 (2.7)	8.0	<0.001
V-sit reach (Centimeters)	5.5 (1.9)	0.5 (0.5)	5.0	<0.001
Push ups (Repetitions)	12.7 (2.8)	4.5 (1.3)	8.2	<0.001
One mile test (Minutes)	10.6 (3.1)	20.3 (3.2)	9.7	<0.001

DISCUSSION

The vital indicators of the obese and non-obese children post 6MWT showed significant difference in our study indicating that presence of obesity affects the cardiovascular health of obese children. The results are in line with earlier research on this subject. In a cross-sectional study by Pathare et al. obese children were found to have higher SBP following the 6MWT (Pathare et al., 2012). Another study demonstrated hypertension in obese children even without exertion (Rajet et al., 2007). A derangement of cardiovascular and pulmonary functions was also determined in obese adolescents (Nageswari et al. 2007). Several other studies have also documented adverse effects of obesity on cardiac autonomic modulation and respiratory functions (Farah et al., 2013; Dixon and Peters 2018; Rodríguez-Colón et al., 2011; Freitas et al. 2014;Farah et al. 2018; Palmeira et al. 2017). Reassuringly, previous research has also indicated that in obese youngsters, increased physical activity during leisure time improves lung and heart health. (Farah et al., 2018; Palmeira et al., 2017) .All the above mentioned studies strengthen our conclusion that vital parameters are altered in obese children more than normal weighed ones after 6minute walk test.

Obese children in our study performed worse on indices of physical fitness compared to non-obese children. Such deterioration in physical fitness with increasing BMI has been observed in previous studies. The BMI and six measures of physical fitness were shown to have non-linear associations in a cross-sectional study of 8548 college students in China. Subjects in the normal weight category had better performance in indices of physical fitness compared to underweight, overweight or obese subjects (Chen et al., 2020). A Taiwanese study on normal weight and obese children, also showed that the physical fitness index declined in a curvilinear manner with increasing BMI (Huang and Malina, 2007). Poor physical fitness assessed by five fitness indicators was also observed in children having BMI >25kg/m2 by other authors (Bi et al., 2019; Köchli et al., 2019; Xu et al., 2020; Huang and Malina, 2007 ; Mak et al., 2010). Obese children were seen to be lacking in ability to take on sports skills because of decreased performing capabilities (Ceschia et al., 2016). A recent study has also shown that higher BMI is associated with lower working memory, cognitive flexibility, planning, attention in children which lowers their sprint performance and muscular strength. This supports our findings that obese children are less physically fitness than normal weighed children. It is therefore desirable that adequate levels of physical activity to maintain physical fitness is advised to obese children to avoid harmful effects of obesity on cognitive and motor skills.

Our study has some limitations. It was conducted during the COVID-19 pandemic times in our region which could have some impact on the results of fitness parameters (Dayal et al., 2020) .Recent data indicates that pandemic restrictions affected fitness of children in addition to the body composition changes (Rúa-Alonso et al., 2022). We also did not quantify the daily physical activity to understand if it had some effect on fitness parameters.

In conclusion, our study demonstrates alterations in vital parameters in obese children compared to their non-obese peers. Children with obesity also performed poorly in indices of physical fitness. There is need to conduct larger studies on modifiable biological and behavioral factors to improve physical activity and fitness in children with simple obesity.

Conflict of interests

The authors have no conflict of interests to declare. No financial support was received for this study.

Ethics Statement

The study protocol was approved by the Institute Ethics Committee (INT/IEC/2021/SPI-1550) on 25th October 2021. Prior to the inclusion of the children in the study, informed consent from parents and assent from the children was obtained.

Author Contributions

Study Design, SP, SB; Data Collection, SB, APS,SP; Data Interpretation, SP, PG; Manuscript Preparation, SP,PG,SB; Literature Search, SP,PG,SB,APS. All authors have read and agreed to the published version of the manuscript.

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