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TO COMPARE THE EFFECT OF BODY MASS INDEX (BMI) ON PEAK EXPIRATORY FLOW RATE (PEFR) AND FUNCTIONAL CAPACITY OF SCHOOL GOING OVERWEIGHT AND OBESE PEDIATRIC POPULATION OF ANAND CITY: A CROSS SECTIONAL ANALYSIS

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ABSTRACT

Background: Childhood obesity is one of the major problems in public health worldwide. Due to it, approximately all systems of the body suffer from hazardous adverse effects. overweight or obese population, they might observe compression on thoracic cavity, leading to restriction of diaphragmatic movement, causing increased load on muscles of respiration, and might ultimately result in decreased lung volumes and flow rates and indirectly reducing functional capacity.**Objective:** To compare the effect of Body Mass Index (BMI) on Peak Expiratory Flow Rate (PEFR) and functional capacity of school going overweight and obese paediatric population of Anand city.**Methods:** Screening method was used to derive participants matching with inclusion criteria. A total of 100 participants were divided into 2 groups as per their BMI into overweight and obese pediatric population. All the participants were assessed for PEFR and 6 Minute Walk Test (6MWT). Outcome variables were compared with predicted values within the group and participants PEFR and 6MWT values were compared between both groups.**Results:** The mean participants' values with SD of PEFR were 241.40 ± 61.89 and 245.90 ± 60.92 whereas for 6MWT were 493.17 ± 40.37 and 481.01 ± 42.26 respectively for Group A and B.**Conclusion:** Present study concluded that both the variables PEFR and functional capacity reduces in both groups with increase in the BMI. When compared PEFR, it was more affected in overweight population whereas functional capacity was more affected in obese population.

Keywords: Body Mass Index, Peak Expiratory Flow Rate, School, Overweight, Obese pediatric population.

INTRODUCTION

Paediatrics as a branch can be defined as a multifaceted specialty which includes children's physical, psychosocial, developmental, and mental health. According to the US Department of Health, Food and Drug Administration the age range is classified as : (1) infancy, between birth to up to 2 years of age; (2) childhood, from 2 to 12 years of age; and (3) adolescence, from 12 to 21 years of age. From them the school going paediatric student population age ranges from 2.5 years to 16 years[(1)]. According to World Health Organization(WHO), the Body Mass Index(BMI) is defined as the method of utilizing an individual's height and weight to classify them into underweight, normal weight, overweight and obese categories[(2)]. Criteria for Indians: 18.5-22.9- Normal, 23-24.9- Overweight, 25-29.9- Obese, ≥30- severe obesity.

According to recent data of National Health and Nutrition Examination survey, prevalence of obesity is as high as around 18.5% in the age group of 2-19 years old, for pediatric population aged 6-11 years it is 4.2% to 15.3%, which carry forwards in adolescent population aged 12-19 years is 20.6% [(3)]. Childhood obesity is one of the major problems in public health which affects majority of the countries of the world. Due to obesity approximately all systems of the body suffers from hazardous adverse effects in later on stages[(4)]. It has been reported in respiratory system that, due to fat accumulation in the trunk region of the overweight or obese population, they might observe compression on their thoracic cavity, leading to restriction of the diaphragmatic movement, causing increased load on muscles of respiration, which might ultimately result in decreased lung volumes and flow rates[(5)]. The function of lung decreases as BMI increases. Normal BMI is connected to normal Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV1)[(6)]. In obese patients, due to excess adiposity, there is increased production of inflammatory cytokines and immune cells which has direct relationship with reduction in lung function and also this respiratory compromise leads to respiratory disorders[(7)]. Obesity is found to increase changes in the respiratory system like breathlessness during exercise which is a symptom of airflow limitation and recognized as a risk factor in developing respiratory disorders of airway obstruction and restriction[(5)].Peak Expiratory Flow Rate (PEFR) is the maximum rate of airflow that can be generated during forced expiratory maneuver starting from Total Lung Capacity(TLC). By assessing Peak Expiratory Flow Rate (PEFR), an individual can be directly assessed for Forced Expiratory Volume in one second (FEV1) due to its high correlation and presence of impairment in respiratory function can be found out [(5)(8)].Along with alteration in respiratory functions, overweight and obese pediatric population might observe intolerance to physical exercise due to systemic changes which eventually ends up in reduction in physical and functional capacity. Therefore, 6 minute walk test – a submaximal exercise testing can be added in assessment of respiratory function of overweight and obese pediatric school going population[(9)].

As per the available current literatures, it is possible to effectively cure the respiratory disorders

at every age of life span. However, early detection of risk factors will provide additional benefits in eradicating the possibilities of development of respiratory system abnormalities. Extending obesity from pediatric population to adolescents and furthermore is a root cause of respiratory disorders. Hence, assessment of the parameters like Peak Expiratory Flow Rate(PEFR) and 6 Minute Walk Test(6MWT) might provide the overview of alterations occurring in respiratory system. Also, there are lesser number of evidences available comparing the effect of BMI on the above mentioned parameters of school going overweight and obese paediatric population. Therefore, this study will be conducted with an aim of finding out the effect of body mass index (BMI) on peak expiratory flow rate (PEFR) and functional capacity of school going overweight and obese paediatric population of Anand city.

METHODOLOGY

Study Design: Comparative cross-sectional analysis

Participants: Overweight and obese school going paediatric population ((Group A – Overweight school going paediatric population) (Group B – Obese school going paediatric population)

Inclusion Criteria:

- Both males and females
- 7-12 years of school going pediatric population
- Clinically healthy and willing to participate children

Exclusion Criteria:

- Non cooperative
- School going paediatric population having physical and mental illness.
- Children having respiratory infection, any other respiratory disease or musculoskeletal deformities, known neurological disorders, operated with congenital or known cardiac conditions, children with metabolic disorders.

Intervention/Procedure: A comparative cross sectional analysis study was conducted on overweight and obese school going paediatric population of Anand city after the approval from institutional ethics committee. 100 participants were included in the research as per the inclusion and exclusion criteria and were divided into two groups based on their BMI.

For the data collection procedure, a total of 14 schools from Anand city that met the study criteria were approached and study procedure was explained. Permission was taken from the respective authorities in the form of written application. Out of this 9 schools provided consent and allowed the researchers for data collection.

Screening method: For extraction of participants meeting with our inclusion criteria, screening method was used. All the school going paediatric population aged 7-12 years were screened for height and weight. Participants meeting with inclusion criteria were selected on the basis of their BMI measurements.

A total of 14 schools were approached out of which 9 schools permitted for carrying out the screening. In total, 1006 participants were assessed for height and weight and BMI and out of them 100 participants were included for the study according to the inclusion and exclusion criteria.

The participants having BMI ranging 23.0-24.9 kg/m2 was classified as overweight, The participants having BMI ranging ≥ 25 kg/m2 was classified as obese as per the WHO criteria for Asian population. Participants were explained about the study details, and requested to be the part of study and interested participants were divided into 2 groups.

Group A (overweight school going paediatric population): BMI 23.0-24.9 kg/m2

Group B (obese school going paediatric population): BMI ≥ 25 kg/m2.

There were 50 participants in each group who were assessed for peak expiratory flow rate and functional capacity in the form of 6 Minute walk Test.

PEFR was measured in L/min with a standard Wright Peak Flow Meter (60–800 L/min). At rest and in a standing position, each child blew three times, without nose clip, into a standard Wright peak flow meter. Instructions and method of carrying out the test were demonstrated to the participants. Each participant made 3 PEFR maneuvers and the highest value was recorded

The 6 MWT was performed indoors, along a long, flat, straight, enclosed corridor with a hard surface. The walking course was 30m in length. The length of the corridor was marked every 3m. The turnaround points were marked with a cone (such as an orange traffic cone). A starting line, which marked the beginning and end of each 30-m lap, was marked on the floor using brightly colored tape. The participants walked back and forth around the cones in the hallway. Number of laps completed by the participant throughout the test was counted. The additional distance covered (the number of meters in the final partial lap) was recorded using the markers on the wall as distance guided. The total distance walked was calculated and recorded.

PREDICTION OF NORMAL PEAK EXPIRATORY FLOW RATE VALUE FOR INDIVIDUAL:

• As per the regression analysis the value of Peak expiratory flow rate was calculated by using regression equation for weight of every individual. (75)

• For males PEFR = 187.1 + Weight x 3.84

• For females PEFR = 221 + Weight x 2.30

• The derived value from the equation was compared with the highest value of Peak Expiratory Flow Rate (PEFR) trial and based on that, the participant was declared having normal value or reduced value respectively. (75)

• Pre and post vitals were taken in the form of Heart Rate, Respiratory Rate, Rate of Perceived Exertion (RPE), SPO2. Post vitals were taken at intervals of every 2 minutes until vitals became stable. (75)

• Calculation of functional capacity of an individual using Karvonen's formula: (75)

 Maximum Heart Rate (MHR) = 220 - Age Heart Rate Reserve = Maximum Heart Rate - Resting Heart Rate Target Heart Rate = [(Maximum Heart Rate - Resting Heart Rate) * 40%60% Intensity] + Resting Heart Rate .

Outcome Measures: 1. Peak Expiratory Flow Rate (PEFR) 2. 6 Minute Walk Test (6MWT)

Statistical Analysis: The Shapiro-Wilk normality test was conducted to assess the distribution of the data. The results indicated that the data follows nomal distribution (Group A: W= 0.9827, p=0.6722 ; Grroup B: W= 0.9713 , p=0.2616), confirming its parametric nature. Descriptive statistical analysis (mean (SD) and frequency (%) was used to depict the profile of patient.

To find out the correlation between Body Mass Index (BMI) and affection in Peak Expiratory Flow Rate (PEFR) and Functional capacity Pearson's correlation analysis was performed. The Mean and SD values of Peak Expiratory Flow Rate (PEFR) and 6 Minute Walk Test(6MWT) of both groups was compared via using Paired T-test to find out more presence of more significant affection in the group.

RESULTS

Statistical analysis of the study was done using SPSS version22 software. The data was entered into the computer using Microsoft Excel sheet, tabulated and subjected to statistical analysis. Descriptive statistical analysis mean (SD) and frequency (%) was used to depict the profile of patient. To find out the correlation between Body Mass Index (BMI) and affection in Peak Expiratory Flow Rate (PEFR) and Functional capacity Pearson's correlation analysis was performed. The Mean and SD values of Peak Expiratory Flow Rate (PEFR) and 6 Minute Walk Test(6MWT) of both groups were compared via using T-test to find out more presence of more significant affection in the group. The Mean and SD values of Peak Expiratory Flow Rate (PEFR) and 6 Minute Walk Test(6MWT) of both groups were compared via using independent sample ttest to find out presence of more significant affection in any of the group.

Table 1: Baseline characteristics

	GroupA	GroupB	Total
Males	19	26	45
Females	31	24	55
Total	50	50	100

Table 2: Mean age and Body Mass Index (BMI)

	GROUPA	GROUPB
MeanAge ±SD	11.6±0.60	11.84±0.42
MeanBMI±SD	23.806±0.59	27.396±2.53

Table 3: within group analysis (group-a)

	MEAN±SD		t-value	p-value
	Predicted	Participants		
PEFR	351.16±30.88	241.40±61.89	13.29	0.000
6MWT	516.16±12.32	493.17±40.37	3.93	0.000

Table 4: within group analysis (group-b)

	MEAN±SD		t-value	p-value
	Predicted	Participants		
PEFR	392.14± 50.60	245.90± 60.92	16.15	0.000
6MWT	519.15± 12.57	481.01±42.26	6.35	0.000

Interpretation : The comparison portrays that the values of participants PEFR and 6MWT were significantly reduced in both groups. (p>0.05)

Table 5:between group analysis

Groups	Participants'	MEAN± SD	t-value	p-value
A	PEFR	241.40± 61.88	-3.66	0.00
	6MWT	493.17± 40.37	1.47	0.03
B	PEFR	245.90± 60.93	-3.66	0.002
	6MWT	481.01± 42.27	1.47	0.034

Interpretation: It can be stated that the values of PEFR were significantly reduced in Group A as compare to Group B. In 6 MWT, it was found that Group B showed more statistically significant reduction in comparison with Group A.

Table 6: Co-relation analysis between Body Mass Index (BMI) and Peak Expiratory Flow Rate (PEFR)

	BMI		N
PEFR	R	p	
GroupA	0.054	0.71	50
GroupB	0.031	0.83	50

Interpretation : In order to find out the relationship between BMI and PEFR, although both the variables are inversely proportional, the linear regression analysis shows statistically weak co-relation between both the variables.

Table 7: Co-relation analysis between Body Mass Index (BMI) and Functional capacity (6 Minute Walk Test)

	BMI		N
6MWT	r	p	
GroupA	-0.06	0.69	50
GroupB	-0.16	0.26	50

Interpretation: In order to find out the relationship between BMI and 6MWT (functional capacity), although both the variables are inversely proportional, the linear regression analysis shows statistically weak negative co-relation between both the variables.

DISCUSSION

This study aimed to compare the effect of Body Mass Index (BMI) on Peak Expiratory Flow Rate (PEFR) and functional capacity in overweight and obese school-going children in Anand city. The results showed that an increase in BMI is associated with a decrease in respiratory function and overall physical endurance, which aligns with current literature. PEFR was assessed using a Mini Wright Peak Flow Meter, while the 6-Minute Walk

Test (6MWT) was used to evaluate functional capacity. Statistical analysis using paired and independent t-tests showed a substantial reduction in PEFR and 6MWT performance in both overweight and obese groups. Pearson's correlation analysis also revealed a strong inverse relationship between BMI and both respiratory and functional capacity parameters.

The participants included in both the groups were assessed prior in the form of baseline characteristics age. The mean and standard deviation age values for Group A was 11.6 ± 0.60 and for Group B was 11.84 ± 0.42 suggestive of comparable distribution of participants of both the groups for age variable.

In the overweight group (BMI 23.0–24.9 kg/m²), PEFR values were significantly lower than the predicted values (351.16 ± 30.88 vs. 241.40 ± 61.89, $p < 0.05$). The result was supported by K. Subramanyam et al who concluded that increase in BMI decreases PEFR values.[10] A study by Navia Isaac et al had also reported that the value of PEFR in the overweight group was significantly reduced as compared to the normal BMI group.[11] Kanavi et al in their studies claimed that according to a study on BMI on pulmonary function tests, the possible reason for a decrease in PEFR in overweight individuals may be the fat deposition in the abdomen resisting the movement of diaphragm and in turn reduce the vertical diameter of the thoracic cavity.[12] Due to this compliance of the lungs and thoracic cavity may decrease and increases the load on muscles of respiration, leading to reduction in lung volumes and flow rates, especially PEFR.[12] Similarly, 6MWT results demonstrated reduced functional capacity, with actual walking distances shorter than predicted values (493.17 ± 40.37 vs. 516.16 ± 12.32, $p < 0.05$). Based on the derived results it can be concluded that with increase in the BMI functional capacity reduces. The result was supported by several articles suggestive of possible mechanism reduced physical activity among overweight pediatric school going population. Ravi Manawat and Shweta showed in their research that increase in BMI reduces the functional capacity and aerobic fitness of an individual. The possible mechanism can be with advancing age and reduced physical work results into reduction in muscle mass, muscle strength and maximum oxygen uptake.[13] Reduction in maximum oxygen uptake directly indicates affection in maximum aerobic capacity turning out as a possible cause for reduction in functional capacity.[13] The results were supported by another article of Juozas Raistenkis who had reported from the studies that physical fitness parameters were related to the daily moderate physical activities. Overweight children were less physically active and had lower physical fitness than the normal weight children.[14]

For the obese group (BMI ≥ 25 kg/m²), PEFR was significantly lower than predicted values (392.14 ± 50.60 vs. 245.90 ± 60.92, $p < 0.05$). Mohd Abass Dar et al had in their study had stated that increase in BMI decreases PEFR values. Mafort et al also showed that obesity causes mechanical compression of the diaphragm, lungs, and chest cavity and that might lead to pulmonary damage. Moreover, excess fat may also decrease total respiratory system compliance, increasing pulmonary resistance ultimately reducing the

respiratory muscle strength. It is also notable that metabolic syndrome also changes the lung function and the combination of obesity and metabolic syndrome seems to impair even the lung functions. In obese and overweight individuals, there occurs a strong correlation between lung function and body fat distribution, with more amount of impairment when there is accumulation of fat in the chest cavity and abdomen.[14,15] Functional capacity was also more affected in obese children, as reflected by their lower 6MWT distances (481.01 ± 42.26 vs. 519.15 ± 12.57, $p < 0.05$). Chaudhary et al had the supporting results as the present study and stated that pulmonary function decreases in obesity which might be due to the added mechanical load of adipose tissue which reduces chest wall compliance and causes diaphragm decent leading to decreased functional capacity and hence reduced 6MWD.[16]

Moreover, when PEFR values are compared between the two groups, the obese group had slightly higher PEFR values than the overweight group. It may be due to height variations among participants, as height has a strong positive correlation with PEFR. Research also indicates that taller individuals tend to have higher PEFR values, which also explains the minor discrepancy despite both groups experiencing an overall reduction in lung function. Additionally, factors such as age distribution and environmental influences, including exposure to smoking at home, may play a role in individual variations.[17]

Meanwhile, when discussing the between group analysis between both the groups A and B, the values for participants 6MWD for Group A was more than that of Group B. The mean values for Group A with standard deviation was 493.17 ± 40.37 whereas, for Group B with the standard deviation was 481.01 ± 42.27. The known fact for this is that with the increase in BMI the functional capacity decreases. The decrease in functional capacity leads to decreased distance walked in 6MWT. Therefore, it can be stated that the functional capacity of obese school going pediatric population was more affected as compared to overweight school going pediatric population. Jitti et al had reported that BMI is a well-established predictor of 6MWT performance in obese children.[18] Increased BMI necessitates increased energy expenditure, which can limit physical fitness. Hence the values of the participants were less for Group B (obese school going pediatric population) than the Group A (overweight school going pediatric population). Another study by Ujwal et al had concluded that overweight and obese children showed less functional capacity compared to healthy weight children. They stated that there occurs higher expenditure during walking and altered mechanical efficiency in obese people compared to a lean population. Perhaps obesity increases the cost of supporting body weight because of less mass specific lower limb power. The combination of supporting more weight on the legs and swinging a higher leg probably causes greater metabolic expenditure in obese population during walking, and hence decreased aerobic endurance. The slower walking speed may also simply be a strategy to reduce ground reaction forces and net muscle movements or torque.[19]

When the correlation analysis was done between BMI and the PEFR for both the groups, Group A

had the value of r and p as 0.054 and 0.71 respectively. While Group B had the value of r and p as 0.031 and 0.83 respectively. It was found that both the variables were inversely proportional and the linear regression analysis showed statistically weak correlation between both the variables. Thus, the current study shows that increase in the BMI leads to decrease in PEFR values. The correlation analysis between BMI and 6MWT for the Groups A and B showed the value of r and p as -0.06 and 0.69 respectively for Group A and -0.16 and 0.26 respectively for Group B. Here also, the both the variables were found to be inversely proportional and the linear regression analysis showed statistically weak negative correlation between both the variables. Thus, the current study shows that increase in the BMI leads to decrease in 6MWT values. When the relation between PEFR and distance walked in 6MWT was viewed, it was found that obese individuals had lower PEFR and functional capacity as compared to the individuals with normal BMI. Graziele et had concluded from their studies that obese individuals exhibited lower PEF and walked shorter distances in the 6MWT, indicating a positive correlation between the two variables. They also stated that obese individuals exhibit compromised lung function, characterized by lower forced expiratory flow rate, and this impairment is associated with reduced functional capacity. This relationship can be justified by the fact that obese participants exhibited higher BP as a cardiovascular effect, as well as signs of exhaustion, with high RR and perceived exertion.[20]

Overall, the study confirms that increased BMI negatively impacts both respiratory and functional capacity in school-going children. The results suggest that targeted interventions, such as structured physical activity programs and weight management strategies, may help to manage these effects. Future research should explore longitudinal outcomes and the effectiveness of specific interventions in improving pulmonary function and endurance in overweight and obese pediatric populations.

FUTURE RECOMMENDATIONS:

1. Study can be conducted on larger sample size.

2. The same study can be merged with therapeutic protocols.

3. One more outcome measure can be added VO2 max to assess aerobic capacity.

4. Maximal exercise testing along with ECG monitoring is recommended for more accurate results.

5. Pulmonary function tests can also be included as an outcome measure.

LIMITATIONS

1. The study consisted of small number of participants.
2. There is variation in gender distribution amongst both the groups possibly leads to variations in derived results
3. Lackof normal distribution of ageinboth the groups which plays as a possiblefactor in contradictory results.

CONCLUSION

Pediatric population is nowadays more affected with obesity with highest prevalence in school going children amongst developing as well as

developed countries. And it is well known that obesity is one of the most affecting predisposing factors in developing respiratory impairments. With the advancing age, these respiratory impairments can be life threatening in obese population. As per the available literatures, changes occur in the body due to obesity are modifiable. Therefore, assessment of presence of these impairments becomes necessary in younger age. PEFR and 6MWT (functional capacity) known respiratory parameters which get affected with obesity if assessed in early age, hazardous effects can be prevented. Therefore, this study was conducted in school going overweight and obese school going pediatric population. Positively relating with the other available literatures, it was found out that obesity (increase in the BMI for overweight and obese population) significantly affects PEFR and functional capacity. Based on this, it can be stated that increase in the BMI reduces PEFR and 6MWD in both the groups.

But while comparing we found out that PEFR was more reduced in overweight population whereas, functional capacity was more decreased in obese population. The derived results draw attention towards possibility of more affection of functional capacity as the BMI increased and leading to speedily progression of respiratory impairments.

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