

Peak Expiratory Flow Rate – A Consistent Marker of Respiratory Illness Associated with Childhood Obesity

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Abstract Childhood obesity is a prevalent global health problem that leads to onset of serious health problems. One of such major health problems is respiratory disorders induced by obesity especially in childhood. Peak expiratory flow rate (PEFR) is a convenient tool for quantitative and qualitative estimation of pulmonary function, which can easily be measured by peak flow meter. Present review has been focused to find out the applicability of PEFR as a marker of childhood obesity induced respiratory complications. Several studies revealed that obesity has strong association with PEFR that was significantly lower in individuals with obesity. Such association was attributed to the increased airway resistance and respiratory muscle dysfunction as a result of excess fat deposition. BMI, a good predictor of obesity also exhibited significant correlated with spirometric variables, e.g., FEV₁, FVC, PEFR, etc. Waist to hip ratio has also been found to be an alternative of BMI for prediction of PEFR. Researchers hypothesised that fat accumulation over the chest wall reduces the PEFR mostly among all the pulmonary function indices and negative correlation was observed between pulmonary function parameters and visceral adiposity that in turn establishes that visceral fat deposition negatively affects the pulmonary activities and affects airway hyper responsiveness (AHR) in asthmatic and non-asthmatic children. Evidences further suggest that obesity causes asthma in children. It may further be hypothesized that PEFR is a good marker to diagnose the pulmonary disorders originated as a result of obesity that in turn may be evaluated from BMI or waist to hip ratio.

Keywords: Obesity, PEFR, child, BMI

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1. Introduction

Excessive accumulation of body fat is denoted as Obesity that is an alarming global health problem now-a-days. It is best defined as the body fat which remains over in excess. A 15–20% of body fat for men and 25% of body fat for women are generally accepted as 'normal', but these are not essentially the optimal values, as a 10 to 20% of excess body fat over the usual values is generally considered to be "obesity" [1].

Obesity is one of the major consequences of respiratory problems not only in adults but also in paediatric population [2]. Children are the future generation of the world and therefore the childhood obesity and related health complications is of high concern among health professionals. Assessment of Body Mass Index (BMI) is a reliable tool for categorization of healthy and diseased people in aspect of weight [3], i.e. it is also helpful in measuring the body composition and adiposity among adults and children [4].

PEFR is a convenient tool for quantitative and qualitative estimation of pulmonary function, which can easily be measured by peak flow meter. For monitoring

the respiratory status of obese children, PEFR can be a useful indicator, which can also be helpful for predicting risk of asthma [5]. Present review is therefore focused on the respiratory complications expressed in terms of peak expiratory flow rate (PEFR) in childhood obesity.

2. Aims and Objectives

An increase in total body fat (TBF) in children resulting in an increase in pulmonary defects is becoming a major worldwide problem [6]. It has also been well recognized that obesity is more prevalent among the asthmatic children. Several cross sectional studies showed an association between occurrence of asthma and high BMI [Weight (Kg) / Height (cm)] among adults and children [7-14].

The present review was therefore aimed to discuss about :

- PEFR and its importance as a marker of respiratory status in health and diseases
- Childhood obesity as a global health problem
- Association of respiratory illness with childhood obesity, and
- Whether PEFR can be considered as well as recommended to be a good marker to diagnose the childhood obesity induced respiratory illness.

3. Childhood Obesity: A Global Perspective

Obesity is one of the major emerging public health challenges, worldwide, especially the “Childhood Obesity” [15,16,17,18]. There are huge variations in defining childhood obesity and still now no common standard has been accepted [17]. Different organizations have their definitions for obesity in children. WHO Child Growth Standards define a child from birth to age 5 as obese, who has BMI > 3 standard deviations above the WHO Growth Standard Median [19] and a child of age 5 to 19 is defined to be obese having BMI > 2 standard deviation above the WHO Growth Standard Median [20]. Whereas, according to CDC growth charts, children of age 2 to 19, who have 95th percentile of BMI are considered as obese [21].

Childhood obesity in childhood may lead to a range of physical and psychosocial health complications. Physical health problems mainly include cardiovascular risks due to high blood pressure, high cholesterol and high insulin resistance [2]. An Australian study reported an association between childhood obesity and cardiovascular complications [22]. The other health hazards related to paediatric obesity are respiratory complications, type II diabetes, hepatic problems, orthopaedic and musculo-skeletal problems. Several studies demonstrated the relation between pulmonary complications and childhood obesity. Gundogdu Z et al., [4] reported a significant inverse relationship between BMI and PEF among all age groups. The same negative correlation between BMI and basal FVC, FEV₁, PEF values in children were found by Ulger et al., [23]. Occurrence of type II diabetes among children is increasing day by day [24]. According to Alberti et al., [25]. The simultaneous increase in diabetes (type I and II) and obesity may indicate their inter relationship. A study by Rashad and Roberts, [26] demonstrated a probable relationship between childhood obesity and hepatic disorders like, cholelithiasis (gall stones) and hepatic steatosis (fatty liver disease). Childhood obesity can develop changes in joints which results in continued pain and raises the chances of osteoarthritis in adulthood. Occurrence of orthopaedic complications like Blount disease (tibia vara) [27,28] and Slipped Capital Femoral Epiphysis [29] are also reported. Stovitz et al., [30] obtained a direct relationship between obesity and pain in different joints (hip, knee, ankle) among children when used BMI as an independent variable. Similar opinions are obtained from Li et al., [31]. Psychosocial complications among obese children are another severe emerging problem which mainly includes low self-esteem and depression [32,33].

4. PEFR: A General Overview

Pulmonary function is a complex combination of several processes including movement of air in and out of the lung, i.e. mechanical breathing or external respiration generating ventilation, which is dependent upon the optimum diffusion of gases through alveoli-capillary membrane. PEFR is one of the important parameters in pulmonary function testing that has been evolved as clinical tools for diagnosis, management and follow up of respiratory diseases [34,35,36]. For the assessment of

ventilatory capacity, Peak Expiratory Flow (PEF) rate is considered to be the simplest one among the pulmonary function indices . which was first introduced by Adorn in 1942 as a measurement of ventilatory function and was accepted in 1949 as an index of spirometry [37]. It is defined as “the largest expiratory flow rate achieved with a maximally forced effort from a position of maximal expiration expressed in litres/min” [38]. PEFR is accepted worldwide as the objective indicator of ventilatory capacity and is helpful for diagnosis and management of respiratory illness [39]. It represents the calibre of the bronchi and larger bronchioles undergoing effort dependent reflex constriction [37] and is of major importance in diagnosis and treatment of lung function problems and also in identifying the presence of airflow limitation, assessing it’s severity and variation [40].

4.1. Relation of PEFR with Obesity

Several studies support the association between obesity and PEFR. It has already been reported that PEFR is lower in obese children [4,23]. Kumar et al., [41] reported that pulmonary functions tends to reduce with age, but they also found the PEFR to reduce more in obese individuals in complications to the non-obese group. This kind of association is probably due to the increased airway resistance and respiratory muscle dysfunction as a result of excess fat deposition. According to Tantisira et al. [6], high BMI is positively associated with spirometric variables like FEV₁, FVC, PEF. This kind of association is probably due to the increased airway resistance and respiratory muscle dysfunction as a result of excess fat deposition.

4.2. Factors Affecting PEFR

PEFR is influenced by gender, body surface area, obesity, physical activity, posture, environment & racial differences [42,43,44,45] and also by individual’s physical. This article is mainly focused to be concerned with the obesity. The elementary factors upon which PEFR values depend are voluntary effort, strength of the expiratory muscles, generating the force of contraction, lung volume and airway size and elastic recoil strength of the lungs [44,46,47,48], Height, Weight and Chest circumference are the main determinant factors of PEFR among the physical parameters [49,50]. Azah et al. [51] also reported similar statement for healthy Nigerian children. In pathophysiological conditions PEFR may be affected by the neural systemic integrity, extra thoracic airway obstructions [52]. Some other conditions have principal effects on PEFR such as chronic malnutrition which is responsible for reduction of PEFR probably due to undergrowth of the major airways [53]. Another affecting factor is the air pollution. It is reported that children’s PEFR is reduced by the particular air pollution during summer [54,55].

5. Childhood Obesity and Health Complications

A number of serious complications are related to obesity in children [56] including later heart disease, other chronic diseases like, hyperlipidemia, hyperinsulinemia,

hypertension, early atherosclerosis [5,6], Berenson, Berenson] and also the respiratory problems [4,44,57,58,59,60].

There is every possibility that an obese child will become an obese adult [61,62] who is very much prone to prevalence of obesity induced health abnormalities that may lead to premature death. Lung function may also be affected by obesity in adults [4,63]. Obesity induced anomalies in pulmonary function has been extensively reported in researches and epidemiological studies, mainly reporting the decrement in lung volumes and expiratory flow rates. Similar scanty reports are also available in case of paediatric population [4].

5.1. Prevalence of Respiratory Illness in Childhood with Special Reference to Obesity

Accumulation of fat over the chest wall alters the PEFR mostly among all the pulmonary function indices [64]. Various hypotheses have already been put forward to establish the negative correlation between the pulmonary function parameters and visceral adiposity [45]. In a study [4] 1439 age-matched children were divided into different groups of obese and non-obese children according to their BMI. The study reported significantly lower values of PEFR in obese groups. They designated PEFR as an objective indicator of pulmonary airflow resistance. Association of higher BMI with lower PEFR was also attributed to be a cue for greater risk factors correlated with childhood asthma. Similar negative correlation between BMI & pulmonary function among age adjusted boys and girls was reported by Canoy et al. [65]. These reports with lower values of PEFR in obese children of both the genders depicted as increased respiratory resistance with obesity indicating the high risk of compromised lung function due to obesity [4].

Therefore visceral fat deposition negatively affects the pulmonary activities altering the air flow resistance, thereby alters PEFR. This can be correlated with onset of asthma. Because, obesity in one hand can induce noneosinophilic inflammatory pathways increasing the risk of non-atopic asthma, or on the other hand, it can also affect the Airway Hyper Responsiveness (AHR) both in asthmatic and non-asthmatic children [10,66,67,68,69,70]. Other studies have also reported association between high BMI [Weight (Kg.) / Height (Kg.)] and asthma among adults and children [10,70,71,72,73]. In epidemiological studies the combination of AHR and the symptoms is used as a standard for defining asthma [74]. Litonjua et al., [69] showed an association between increasing BMI and increased risk of symptomatic AHR. Similar results were found by Sposato et al., [75] who showed that for female adolescents obesity may be a potent risk factor than their male counterparts and also the children. But in study with Korean children [76] and Turkish children [23] found to show direct relation between BMI and AHR.

Evidence suggests that obesity is caused by asthma, as asthmatic child lacks physical activity [10,62]. Conversely, girls becoming over weights between the age 6 – 11 years, found 5 – 5.7 times more likely to develop new asthma symptoms at 11 – 13 years of age than the girls who did not become over weight at 6 to 11 years [4,77]. Chinn et al., [78] demonstrated that obesity increases the risk of asthma. There is no such hypothesis have been established

that asthma can facilitate obesity, but there are several studies depicting the association between children obesity and asthma. Another metaanalysis of prospective study by Flaherman and Ratherford et al. [79] reported that the children having high body weight at birth or during childhood are at a greater risk of developing asthma. There are several other studies reporting positive relationship between obesity and asthma in white population [44,80,81,82] as well as in Chinese [69] and Indian population [83].

Sposato et al. [75] reported that obese adolescent females are passed at greater risk than males and children, who has moderate to severe AHR; whereas Chin et al. [78] also found increasing bronchial hyper responsiveness with the increase of BMI in males. However, a contradictory view also exists that asthmatic patients had no correlation between BMI and any of the spirometric indices [59].

El-Baz et al. [84] reported that obese children are more prone to respiratory symptoms like restrictive pulmonary defects, evident small airway obstruction, defects in respiratory musculature, weak effort and coordination along with increased airway resistance than their normal counterparts. They also found an inverse correlation of BMI with most of the pulmonary dysfunctions and recommended the BMI as a good predictor parameter of pulmonary function assessment in obese children. On the other hand, according to Price et al. [85] adiposity is suggested as a significant predictor of reduced PEFR.

A comparative study on pulmonary function measurements in obese and non-obese individuals, reported a significant negative correlation between BMI & PEFR [59]. The study also stated that waist to hip ratio (WHR), the central pattern of fat distribution as a better predictor of PEFR, as it was found to be better correlated with lower PEFR values in adult males. Similar negative correlation between increasing obesity and BMI, along with other obesity indices, like weight – waist circumference, hip circumference, waist to hip ratio have been found in adolescents [86]. In this case also a contradictory finding has been reported in adult males, indicating insignificant association between obesity markers and lung function parameters [87]. Similar contradictory findings have been reported among patients in the European Prospective Investigation into Cancer and Nutrition (EPIC–Norfolk) [65]. Some other studies supported the view that respiratory mechanics can be affected by fat distribution pattern and control obesity, which can be estimated by waist circumference (WC) or by WHR, independent of BMI [88]. We can provide objective information about the fat distribution which is not provided by BMI estimation and it is a better indicator of intra-abdominal fat [89]. As respiratory activity is controlled by the expansibility of diaphragm and high WC is supposed to hinder the diaphragm expansion. These findings indicated that waist to hip ratio (WHR) or waist circumference (WC) can be used as an alternative indicator of obesity instead of BMI for predicting PEFR.

The overall adiposity compresses the chest wall [59], whereas the abdominal fat deposition causes respiratory muscle dysfunction [14]. Increasing level of obesity found to significantly increase the total respiratory resistance and airway resistance in healthy obese subjects [59,90]. Increased abdominal mass or abdominal adiposity restricts the descent of diaphragm into the abdominal cavity which

causes the incomplete expansion of chest and thus the lungs, therefore increasing the thoracic pressure [59,45]. All these lead to reduction of chest wall compliance [86,91], increased respiratory effort due to added weight of breathing as the increased fat mass loads the respiratory apparatus that affects airway closure [4,45,92,93,94]. All these lead to a negative impact on gaseous perfusion. Another study explained that obesity increased the oxygen consumption [48,92,93,95], which was attributed to the fact that increased fat deposition in between the muscles and ribs might have increased the metabolic demand [59].

All the above correlations between pulmonary dysfunction and obesity were from mechanical aspect. But, several studies established some other probable approach of association in between these two, which are biochemical one. Adipose tissue acts as a source of pro-inflammatory cytokines and chemokines, like interleukin-6, tumor necrosis factor-alpha, leptin, interleukin-18, adiponectin by increasing their circulating levels or local concentration, which leads to systemic inflammation and leaves a negative impact on pulmonary function. So, the main bridge is 'pulmonary inflammation' linking the visceral obesity and pulmonary function, which is also the key to asthma pathophysiology [66,96,97].

It has been observed those obese individuals are prone to develop hypoventilation and sleep apnoea syndrome which causes a chronic low levels of blood oxygen and high levels of CO₂. As a result there are chances for the obese people to have respiratory difficulties at lying position [92,93].

For paediatric population Siregar et al. [45] found lower PEFR among obese children than the non-obese children, before and after physical exercise. Physical inactivity and obesity impair several pulmonary function measurements, whereas appropriate aerobic exercise training can partially improve the later by enhancing the respiratory muscle activity. The young individuals having overweight and obesity, habituated to sedentary life style are at a greater risk for respiratory problems and prone to developing chronic obstructive pulmonary diseases at the later stage of the life [61]. So, to avoid several kinds of health hazards, especially the respiratory one, the obese people are required to reduce their bodyweight at younger [45].

Childhood obesity may develop into adulthood obesity, prevention of this rising epidemic is needed at younger age [61]. Another emerging epidemic, childhood asthma is also associated with childhood obesity, which can also be controlled by preventing and treating the obesity during childhood [10].

6. Conclusion

PEFR may be conducted in the clinical settings to primarily evaluate the respiratory health of an individual. The procedure to measure the PEFR is very easy to apply from bed side to field. Therefore it may be used as a parameter of individual marker. Development of general awareness is essential in the context of Childhood obesity induced respiratory problems and proper remedial measures should be advocated in the society on emergency basis. Association of obesity and pulmonary diseases is well documented in the above discussion and therefore necessary measures should be taken at the early

stage of life to avoid the occurrence of obesity induced pulmonary problems at the later stage of life. Waist to hip ratio has also been found to be an alternative of BMI for prediction of PEFR. It may further be hypothesized that PEFR is a good marker to diagnose the pulmonary disorders originated as a result of obesity that in turn may be evaluated from BMI or waist to hip ratio.

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