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A Pilot Study on the Influence of Macronutrients towards Childhood Obesity among South Indian Population

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ABSTRACT Childhood obesity and associated comorbidities is a rapidly developing health problem in India. The aetiology of obesity is multifactorial, but is predominantly related to nutrient imbalance. Increased calorie intake and its macronutrient composition in the diet have a major contribution towards obesity. The present study aims to examine the influence of macronutrients on childhood obesity. The study included 50 obese and 50 non-obese children in the age group of 4-12 years. BMI was calculated and compared with BMI charts for age. Alpha food frequency questionnaire was used for nutritional assessment. Total calorie consumption showed a significant difference between obese and non-obese children ($p<0.001$) with 2068.5 ± 245.5 kcal in obese children and 1819.5 ± 249.2 kcal in non-obese children. No significant difference was observed in the macronutrient proportion in the study population. The screen time between obese children (6.5 ± 3.1 hours) and non-obese children (1.7 ± 0.7 hours) showed a significant difference ($p<0.001$). Increased total calorie consumption and screen time contribute towards childhood obesity, whereas, macronutrient proportions did not have an influence on childhood obesity among the study population.

INTRODUCTION

Obesity is considered a major non-communicable epidemic, strongly associated with increased risk towards diabetes, dyslipidaemia, hypertension and metabolic syndrome. The prevalence of obesity is increasing worldwide, thus underlining the necessity to devise strategies for its prevention and control (Ng et al. 2014). The global prevalence of childhood obesity was around 150 million in 2019 and has been estimated to increase over 206 million by 2025 (Lobstein and Brinsden 2019). There is an increase in obesity among children and adolescents in South Asian countries (Jayawardena et al. 2017). Obesity assessment studies conducted across 38,000 children in India (from the northern, central and western zones) reveal that about 24.4 percent of children were overweight and the prevalence of central obesity was higher in female children and adolescents than in males (Misra and Shrivastava 2013). It is evidenced that there has been a surge in the incidence and prevalence of obesity in Indian children (Kumaravel et al. 2014; Ranjani et al. 2016).

Multifactorial causatives such as age, gender, ethnic differences, genetic predisposition and environmental factors are associated with childhood obesity and several studies indicate that the balance between physical activity and metabolic response to dietary intake is a critical factor in determining obesity incidence (Madsen et al. 2008). Although screening programs to determine the prevalence of childhood obesity have been advocated in private and government schools across India, literature pertaining to recommendations of diet programs that would enable weight loss and prevention of weight gain, are very limited (Ranjani et al. 2016). In particular, studies addressing the importance of macronutrients and the influence of isocaloric macronutrient substitutions is least defined in the South Indian population.

The prevalence of obesity is rapidly growing due to sedentary lifestyle and consumption of high calorie food (Ahirwar and Mondal 2019). The family environment and genetic risk factors such as satiety response genes play an important role in childhood obesity (Persky et al. 2021). Although the prevalence and incidence of childhood obesity varies widely on a global scale, dietary practices and socio-economic status contribute significantly to obesity in Indian children. The prevalence of

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obesity is higher among the urban populations and individuals from high socioeconomic status that is increasing in South India. It has also been observed that in lower- and middle-income countries like India, consumption of high calorie diet and other factors such as sibling obesity commonly contribute for obesity in children, adolescents (Katzmarzyk et al. 2016; Kuriyan et al. 2018).

Carbohydrates, proteins and fats are the macronutrients that are considered as sources of energy and necessary building blocks. The role of individual macronutrients in the development of obesity remains controversial (Grech et al. 2018). The intake of dietary energy and macronutrients are essential for estimating appropriate dietary intake and nutritional interventions. Macronutrient composition in the diet has a major contribution towards obesity and other metabolic diseases (Wali et al. 2021; San-Cristobal et al. 2020). It influences hormonal secretion from the gut, which is sensed by hypothalamic centres and controls the sense of satiety and hunger, and in some cases, metabolism (Madsen et al. 2008). Nutritional intervention in obesity management is primarily inclusive of restricted calorie intake, macronutrient restrictions and macronutrient calorie modulations (isocaloric diet) (Tay et al. 2008).

The increase in prevalence of obesity in most developing countries is attributed to the Westernised nutritional transition. In such transitions, there is a marginal increase in the consumption of high-calorie diets and a decrease in physical activity (Imamura et al. 2015). Therefore, weight loss and prevention of weight gain strategies focus on increasing the physical activity and energy expenditure with decreasing calorie intake. Such strategies are further corroborated by the detailed studies in adults that reveal isocaloric diets with differences in the macronutrient input and modulated energy efficiency, contribute significantly towards weight loss (Bray et al. 2012; Wycherley et al. 2012). Further, studies from Western countries indicate that isocaloric diets with a high carbohydrate, low fat and very low carbohydrate, high fat diets are successful in aiding maximal weight loss (Tay et al. 2008; Berkowitz et al. 2011).

Studies investigating childhood obesity in the Asian population indicate that higher intake of macro and micronutrients among children (2-6 years) are associated with obesity (Piernas et al. 2015). Interesting detailed studies in school children that assessed the isocaloric substitution of starch instead of dietary sugar indicate that restricted calorie maintenance and meal or snack substitutions may be equally beneficial in school children (Deepa et al. 2003; Lustig et al. 2016). Children exposed to screens like computer, television or mobile phones for longer duration may have an increased risk of obesity due to lack of physical activity and consumption of high-calorie food with sedentary behaviour leading to lower energy expenditure (Maher et al. 2012; Shang et al. 2015). Although, several association studies are being carried out globally in determining the influence of macronutrients on body mass index (BMI), gender, socio-economic status, dietary preferences, etc. in childhood obesity, there is a lack of data in the Indian population, especially south Tamil Nadu. Hence, the present study proposes to examine the influence of macronutrient proportions on childhood obesity.

Objective

The study was aimed to examine the influence of macronutrient proportions like carbohydrates, proteins and fats, towards childhood obesity among the South Indian population in the age group of 4-12 years.

METHODOLOGY

Study Design and Subjects

This was an observational cross-sectional study including 50 obese children and 50 non-obese children in the age group of 4-12 years belonging to various schools across Madurai. Children who attended the obesity clinic for weight reduction were randomly selected. In obese children, BMI was above the 95th percentile for age. Non-obese, age matched, control children were randomly selected from the regional population. Further, socio-demographic details pertaining to age, sex, socioeconomic status, educational status, physical activity, dietary preferences, and family history for obesity, were collected. Clinical assessment was done to exclude obese children with secondary causes of obesity like genetic and hormonal imbalance. Children with obesity related comorbidities like diabetes, dyslipidaemia and hypertension were excluded. The study was conducted in the tertiary care endocrinology centre. The ethical clearance for the study was obtained from the institutional ethics committee (Alpha Hospital and Research Centre: EC/10/2019).

Dietary Assessment

The information on food and nutrient intake was collected by a well-trained dietician using a modified food frequency questionnaire (FFQ) called Alpha FFQ. Alpha FFQ included the type and quantity of food consumed to assess the calorie intake and macronutrient proportions. The type of food refers to the food items prevalent in the population such as *idli, dosa, pongal*, etc. The quantity of food was determined by using models for different sizes of *idli/dosa*, standard cups/spoons of different quantities, models for various sizes of fruits and vegetables.

The researchers used 24-hour dietary recalls for three consecutive days to assess the individual levels of total energy intake and macronutrients proportion per day (Zhao et al. 2018). Fasting and feasting days were excluded. According to the inputs, related food items would be grouped together and nutrient intake was calculated based on the previously published/established data (ICMR) (Deepa et al. 2003; Sowmya et al. 2016).

Anthropometric Measurements

Accurate anthropometric measurements were done by standard techniques. Weight (in kg) and height (in cm) were measured with minimal clothing and without footwear to the nearest 0.1kg and 0.1cm, respectively. The BMI was calculated for all the participants and plotted for age in the Indian academy of paediatrics BMI charts. Childhood obesity was defined by using these BMI charts. If the BMI was above the 95th percentile for age, then they were considered obese (Khadilkar and Khadilkar 2015).

Screen Time

Screen time was calculated with the time spent in a day on any type of screen like watching television, working on the computer, playing video games and using mobile phones.

Statistical Analysis

The collected data were entered in a Microsoft Excel sheet and after data cleaning, analysis was performed to describe the prevalence of obesity among children. The parametric data were presented as mean ± standard deviation. Independent samples t-test was used for comparison between the obese and non-obese children. The p-value of less than 0.05 was considered statistically significant.

RESULTS

In this study, a total of 50 obese children of age 10.4 ± 1 years and 50 non-obese children of age 10.1 ± 0.9 years were recruited on the basis of BMI plotted for age in BMI charts, as mentioned in the methodology. The BMI of obese children was 26.5 ± 1.8 kg/m^2 and that of non-obese children was 17 ± 0.7 kg/m^2. The baseline characteristics of obese and non-obese children are tabulated in Table 1. The total calorie consumption showed a significant difference ($p<0.001$) between obese and non-obese children, with 2068.5 ± 245.5 kcal in obese children and 1819.5 ± 249.2 kcal in non-obese children. However, there was no significant difference in the percentage of carbohydrate, protein and fat consumption between obese and non-obese children. The macronutrient intake was 67.4 ± 10.8 percent of carbohydrates, 15.1 ± 5.1 percent of proteins and 17.4 ± 11.6 percent of fats in obese children, and 65.1 ± 4.8 percent of carbohydrates, 16.3 ± 3.7 percent of proteins and 18.1 ± 8.8 percent of fats in non-obese children. In addition, there was a significant difference ($p<0.001$) in screen time between the obese (6.5 ± 3.1 hours) and non-obese children (1.7 ± 0.7 hours).

DISCUSSION

Current approaches in obesity management in children and adolescents recommend dietary

Table 1: Baseline characteristics of obese and non-obese children

General characteristics	*Obese children (50)*	*Non-obese children (50)*	*p value*
Age (yr.)	10.4 ± 1	10.1 ± 0.9	0.0628
BMI (kg/m^2)	26.5 ± 1.8	17 ± 0.7	**<0.001**
Screen time (hrs)	6.5 ± 3.1	1.7 ± 0.7	**<0.001**
Total calories (kcal)	2068.5 ± 245.5	1819.5 ± 249.2	**<0.001**
Carbohydrates (%)	67.4 ± 10.8	65.1 ± 4.8	0.0921
Proteins (%)	15.1 ± 5.1	16.3 ± 3.7	0.0938
Fats (%)	17.4 ± 11.6	18.1 ± 8.8	0.3674

Values are presented as mean ± standard deviation. p values were calculated using independent samples t-test. p values in boldface indicate statistical significance.

modulations, increased physical activity and cognition-based approaches that would ultimately enable weight loss (Piernas et al. 2015). Dietary modulations include calorie restriction and altering the proportions or quality of macronutrients. It is important to know the dietary pattern of an individual before planning for any dietary intervention.

The results show that increased calorie consumption and increased screen time contribute to childhood obesity. Similarly, Dehghan et al. (2005) have reported that increased calorie consumption and decreased physical activity play a major role in childhood obesity. Moreover, it has a significant effect on physical and psychological health of the children. Joshi and Mohan (2018) suggest that though dietary interventions are followed, the total calorie intake causes weight gain. Hence, a reduced calorie intake with moderate carbohydrate and fat diet with monounsaturated fats and sufficient protein with green leafy vegetables is considered a better alternative diet.

Weight gain is contributed by altered macronutrient composition in the diet with increased consumption of high-glycaemic foods and sugar-sweetened beverages (Madsen et al. 2008). The calories obtained from various macronutrients are not equal towards energy management and weight control, but the interactions between fats, carbohydrates and proteins contribute to the energy gained (Forouhi et al. 2018). In addition, consumption of high-calorie foods, with high levels of saturated fats, sodium, and sugar is a major risk factor in causing childhood obesity (Keough 2018). One possible mechanism for combatting obesity is through dietary intervention. However, the optimal macronutrient composition and distribution is unknown. Continuous research aims to understand the effect that, quantity and quality of macronutrient consumption at specific meal times can have on appetite, body composition, metabolic health, and energy expenditure.

Several dietary approaches based on macronutrient composition and food patterns have been reported for successful weight loss. A high-protein low-carbohydrate diet compared to a high carbohydrate low-protein diet has been reported to maintain energy balance (Martens et al. 2015). Commonly recommended diets based on macronutrient contents are low fat, low carbohydrate-high fat, low carbohydrate-high protein, and based on restriction of specific food items are paleo diet with high protein, Mediterranean, and intermittent fasting diet. These diets induce satiety or reduce the appetite (Aaseth et al. 2021; Freire 2020). Therefore, dietary intervention may be a potential method for the prevention and treatment of childhood obesity. Though the researchers did not find altered macronutrient proportions, dietary interventions with reduced macronutrients and altered the macronutrient quality as mentioned in these studies may help to reduce the body weight.

Screen time contributes to sedentary behaviour, which has a major role in causing childhood obesity. Fang et al. (2019) have reported total screen time to be a risk factor associated with childhood obesity, which is in line with the study. There are several other factors that contribute towards the risk of childhood obesity. Insufficient sleep, psychological stress and altered sleep time play a major role in obesity among children and adolescents (Deng et al. 2021). Moreover, increased risk of obesity exists in children of educated parents, due to higher employment and lack of personal care to their children resulting in sedentary behaviours and increased BMI (Karki et al. 2019). The intake of processed high calorie diets and increase of total calorie consumption due to the coronavirus disease (COVID-19) pandemic in 2019 with mobility restrictions may be a risk factor leading to obesity (Rundle et al. 2020).

The study clearly demonstrates that there is an increase in total calorie consumption among obese children. However, macronutrient proportions in diet do not differ significantly among obese and non-obese children. Likewise, no significant association between macronutrients intake and obesity has been reported in Koreans (Kim and Song 2019). Thus, the childhood obesity is a global epidemic, whose increasing prevalence should be controlled and prevented for the future health of the children.

CONCLUSION

An increase in calorie consumption and screen time contribute to childhood obesity. The macronutrient proportions have no influence on obesity among the study population. Childhood obesity can be prevented by the restriction of calorie intake and increase in energy expenditure.

RECOMMENDATIONS

Health education and motivational counselling to children on obesity prevention and importance of nutrition are the essential criteria for the prevention of excess calorie intake and reduction of weight gain. Parents and children should be educated regarding the future impact of childhood obesity. Awareness programs to decrease total calorie intake and increase energy expenditure through exercise are the key to prevent childhood obesity.

LIMITATIONS

The present pilot study is a cross-sectional study conducted with a small sample size of the total population. The smaller sample size is a major limitation of the study. The physical activities of the participants are not assessed, because the primary objective of the study is to focus on macronutrients proportions. Further, prospective studies with large sample size are essential to evaluate the effects of macronutrient quality and quantity on childhood obesity.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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