RESEARCH PAPER

# Potential Factors Related to Waist Circumference in Urban South Indian Children

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**Objectives:** To identify important factors (linked to lifestyle, eating and sedentary behaviors) relating to waist circumference among urban South Indian children aged 3 to 16 years.

**Design:** Cross sectional.

**Setting:** Urban schools of Bangalore, from August 2008 to January 2010.

**Participants:** 8444 children; 4707 children aged 3-10 years and 3737 children aged 10-16 years.

**Methods:** Data were collected on the frequency of consumption of certain foods, physical activity patterns, sedentary habits at home, sleep duration and behaviors such as habits of snacking, skipping breakfast, eating in front of television and frequency of eating out. Simple linear regression analysis of waist circumference on various food items, physical activity, behavior and parental BMI were performed. A path model was developed to identify potential causal pathways to increase in waist circumference.

**Results:** Increased consumption of bakery items, non vegetarian foods, increased television viewing, decreased sleep duration, eating while watching television, snacking between meals, family meals, skipping breakfast (in older children), and parental BMI were found to be related to waist circumference. Older children possibly under-reported their intake of "unhealthy" foods, but not behaviors.

**Conclusions:** This study identified potential behaviors related to waist circumference in urban school children in India. Longitudinal studies with better measures of morbidity and adiposity are warranted in order to derive casual relationships between various determinants and waist circumference.

**Key words**: *Behavior, Determinants, Obesity, Waist circumference.*

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Body mass index (BMI) is usually recommended for identifying overweight or obese children and youth [1]. It is a measure of excess weight relative to height rather than excess body fat and may be a less sensitive indicator of fatness among children [2]. In our previous study [3], where we derived waist percentile curves for children aged 3 to 16 years, it was observed that greater than 50% of the children were overweight and obese when compared to UK based standards of waist circumference [4], while about 20% were overweight/ obese when the BMI based standards were used [5]. Further, the waist circumference has been validated as a useful predictor for cardiovascular disease risk factors in children [6]. Given the greater prevalence of overweight by this standard, it might be more robust to evaluate associated factors such as lifestyle behavior, food intake, physical activity, and sleep as determinants of overweight. Additionally, while the risk factors for increased BMI have been well described, the relation between potential risk factors and waist circumference is largely unknown.

The aim of the present study was to identify potential factors (linked to lifestyle, eating and sedentary behaviors) related to waist circumference among urban South Indian children aged 3 to 16 years. We also chose to assess clustering of these factors in order to understand which behavior cluster may be the most relevant to target in childhood obesity.

## Methods

The study children were from the PEACH (Pediatric Epidemiology and Child Health) study [3], conducted by

St John's Research Institute, Bangalore. This cross sectional study was conducted on children recruited from 8 urban middle income preschools and schools in Bangalore from August 2008 to January 2010. The annual fees of the schools that were chosen ranged from Rs. 24,000 to 30,000. The inclusion criterion was normal healthy children in the age group of 3 to 16 years. The exclusion criterion was a significant clinical history. The schools were selected by using convenience sampling procedure for operational feasibility. Anthropometric data was collected on 9060 children, while the data on patterns of food consumption, physical activity and behaviors related to foods intake was available for 8444 children; 4707children aged ≤10 years and 3737 children aged >10 years. Waist circumference values above the 75th percentile cut-off [3] was used for classifying abdominal obesity and the Khadilkar, *et al*. [5] cut-off for BMI was used to define overweight/obesity.

*Questionnaires:* Information regarding the study along with the consent sheet was sent to parents and socio-demographic data (age, date of birth, sex, and history of medical illness, parental education, occupation and income, height, weight) collected. The reported monthly frequency of consumption of certain foods (chocolates, sweets, ice creams, bakery items, cakes, soft drinks, fruit juices, fried items, non vegetarian, vegetables, fruits and milk) was recorded. Additionally, physical activity patterns, time spent in tuition after school hours, sedentary habits at home (time spent in television viewing, computer games and tuitions), time spent at games in school and home, and duration of sleep were recorded. Information on certain behaviors that could affect food intake such as habits of snacking, skipping breakfast, eating in front of television, eating with the family and the frequency of eating out was collected. In children 5th grade and below, this questionnaire was filled by the parents. Children of 6th grade and above filled these details themselves in class. The questionnaire was pre-tested to ensure that both children and parents understood the questions; however, it was not subjected to specific validity and reliability tests. The institutional ethical review committee approved the study and parental informed consent was obtained.

*Anthropometry:* Anthropometric measurements of weight, height and waist circumference were measured by utilizing standard methodology [7]. The body weight was measured to the nearest 0.1 kg using a calibrated electronic scale (Essae Teraoka Limited, India). The height was measured to the nearest 0.1 cm. Waist circumference was measured with a non-stretchable tape by trained nutritionists (exerting the same standard pressure on the tape) at the midpoint of the lowest rib cage and the iliac crest, to the nearest 0.1 cm [8], in a standing position during end-tidal expiration. The within and between measurer coefficient of variation was 0.2% and 0.3% respectively.

*Statistical Methods:* The weight and height of the children (measured) and of parents (self reported) were used to calculate their BMI. The intake of food items was recorded as frequency consumed per day or week depending on the food item. These were later converted into four class intervals of frequency of consumption based on author's knowledge of quantity of consumption and contribution of calories, so that such that the children's consumption could be graded into low, low-normal, high-normal and high consumption frequencies (***Web Table* I**). Game activities were assigned into three classes - mild, moderate and vigorous, based on intensity of the activities and their duration [9], yielding an intensity-duration construct called 'games'. For sedentary activities and sleep, duration alone was used as a continuous variable. The number of times the child skipped breakfast in a month and other behaviors such as number of meals eaten with family, snacking between meals, eating in front of television were also used in the analyses.

Data are presented as mean (SD). All analyses were performed separately for two age groups of ≤10 years (younger children) and >10 years (older children), since the data for ≤10 years were filled by parents, and for >10 years by the children themselves. Simple linear regression analysis of waist circumference (WC) on various food items, physical activity, behavior and parental BMI were performed to determine significant predictors without any attempt to adjust for each other, since the aim was to simply identify significant associations and is presented in a bubble diagram. Path analysis is an efficient tool to analyze realistic data where a given parameter may be an outcome with respect to one variable but may in turn become a predictor for other variable. To consider a possible causal mechanism of various factors towards WC and to account for correlation between these determinants, a hypothetic path model was developed. Food groups (***Table* I**) were used for this analysis. The variables that were significantly associated with increase in waist circumference using simple linear regression models were included in a path analysis. This method facilitates the examination of direct and indirect relationships of the various determinants on WC while accounting for co-variances between them. The behavioral parameters were considered as exogenous variables and therefore two of them being binary was permissible. Significant mediating paths of

behaviors through food intake were also included in the model along with co-variances between the parameters. Direct paths to WC and mediating paths that were statistically significant at 5% level are represented in the path diagrams. To test the goodness of fit of the model, RMSEA (root mean square error of approximation, 0.05 or smaller) and Akaike index were used and the best model identified. All analyses were performed using SPSS Version 17 (Chicago, Ill). Path analysis was performed using the RAMONA module of SYSTAT Version 11.

## RESULTS

Boys comprised 56% (*n*=2655) of younger children, and 58% (*n*=2171) of the older children. The mean BMI and WC of the children were 15.5± 2.1 kg/m$^2$ and 55.5±6.7 cm in the younger children and 18.0±3.4 kg/m$^2$ and 68.6±9.2 cm in the older children, respectively. The correlation coefficient between BMI and waist circumference was 0.72 (younger children) and 0.81 (older children) with $P<0.001$. Using the Khadilkar, *et al*. [5] cut-off, it was observed that 22% and 15% of the children were overweight/obese among the younger and older children, respectively.

The statistically significant regression coefficient of individual food items, physical activity patterns, behaviors and parental BMI, which contributed to increase in BMI (kg/m$^2$) and WC (cm), are presented in ***Web Table* II**. Among the food items, the consumption of chicken, fish, bakery items and fast foods contributed to increase in BMI and WC in the younger children, and only to WC in older children. With regard to physical activity; increased duration of TV viewing and decreased duration of sleep contributed to increase in BMI and WC in both the groups of children. Among the behavior patterns, eating while watching TV and snacking between meals increased WC in both age groups, while skipping breakfast increased WC only in older children. Maternal BMI was a strong contributor of increasing WC in both the groups. The factors that contributed to increase in WC are depicted in a bubble diagram (***Fig*. 1**).

**TABLE II** GROUPS OF FOOD, PHYSICAL ACTIVITY AND BEHAVIORS USED IN THE PATH ANALYSIS

| *Variables* | *Items* |
|---|---|
| Food | *Sweets:* Bar/chocolate, Indian sweets, ice-cream |
| | *Bakery:* Cakes, Bun/Biscuits/ Bread/Puff |
| | *Snacks/Fast food:* Samosa, Chats, Potato chips, Mixtures, Burger/pizza/noodles, Fast food |
| | *Beverages:* Fruit juice,Soft drink |
| | *Non Vegetarian:* Chicken, Mutton, Egg, Fish |
| | *Healthy items:* Vegetables, Fruits, Milk |
| Physical activity | TV Viewing, Sleep, Games |
| Behavior | No. of meals with family, Snacking between meals, Eating in front of television, Skipping breakfast |
| Genetic | Maternal BMI, Paternal BMI |

The path diagrams for the younger and older children are presented in **web *Fig*. 1.** Among the younger children there was a mediated effect of behaviors such as "number of eat-outs", "snacks between meals" and "eating in front of TV" through increase consumption of snacks/fried foods, bakery and non-vegetarian, on an increase in WC. In addition, increased consumption of healthy foods also increased WC, suggesting that in this age group irrespective of the kind of food item (healthy/unhealthy), increased intake was associated with increased waist circumference. Increased frequency of skipping breakfast and duration of sleeping had a negative effect on WC, increased physical activity and parental BMI had positive effects on WC.

Among older children, there were significant positive effects of behaviors on consumption of food, but among food only the increased consumption of non-vegetarian items showed a significant effect on WC. Further examination of the data to understand the absence of these relationships showed that, the intake of all food items reported by this age group children who were above the 75th percentile cut-off for abdominal obesity [3], were significantly lower ($P<0.05$) than those reported by children below this cut-off. Increased frequency of "eating in front of TV" had a strong positive effect on WC, while "meals with family without watching TV" had a negative effect on WC. The duration of sleep had a strong negative effect on WC, while parental BMI had a positive effect.

## DISCUSSION

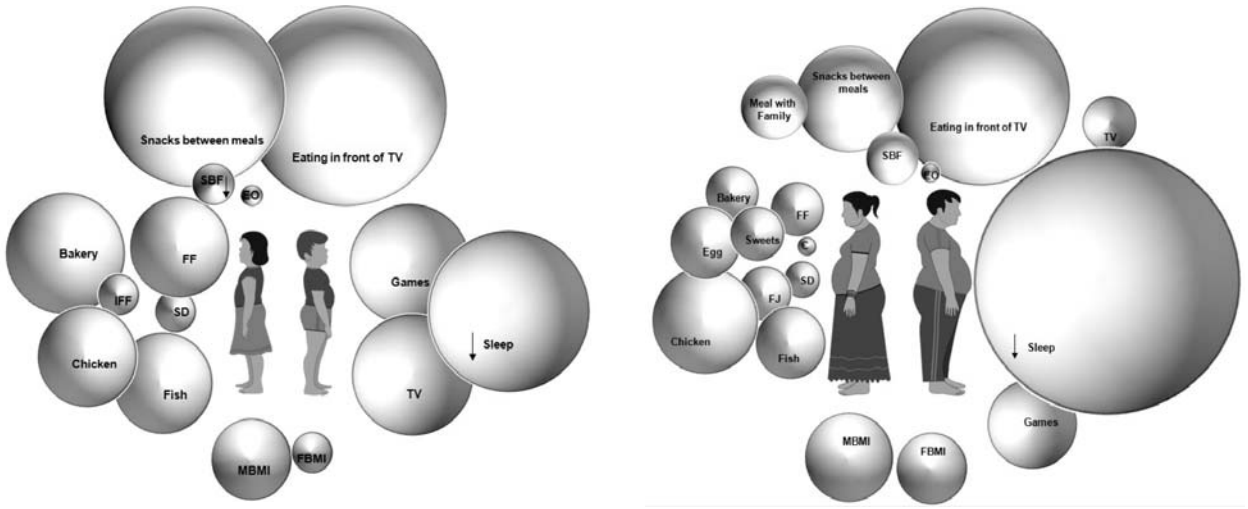
The present study aimed at looking at the potential self reported behavioral factors related to WC in urban school children. While, it is possible that several behaviors could be related to one another, we chose initially to present each behavior individually, to provide a sense of the diversity of drivers of waist circumference in a child's world. We used this initial approach since other analytical strategies (such as the path analysis), which assess correlations between different factors, would inevitably identify only one out of several interrelated factors. However, we also used path analysis to obtain possible

casual mechanisms towards WC and to account for correlation between these determinants. This showed that in the older children, there was a relationship between some eating behaviors and actual foods consumed, but no subsequent path from foods to WC except for non-vegetarian foods, even though a direct link between some behaviors and WC was evident. This suggests that children are likely to underreport their food intake, and this is perhaps because of the often intense messages they receive about the dangers of eating inappropriately. However, they are not yet aware of the effect of their *behaviors* or have not yet been educated intensively about them. Therefore, focus on *behaviors* and foods, rather than foods alone, offers an opportunity to plan better surveillance or interventions. The biggest factors shown in the bubble diagram (***Fig*. 1**) were in agreement with previous studies based on BMI [9-11].

This study also highlights the relationship of important negative behaviors of eating while watching TV, snacking between meals and regular eating out on WC, while a protective effect of family meals without TV was observed; as also observed earlier [12-14]. Skipping of breakfast in the older children was associated with increased WC, which was consistent with earlier studies [15].

Decreased sleep duration was strongly related to WC, and is likely to be due to homework, tuitions and TV viewing in older children. Short sleep duration has shown to be a risk factor for obesity in children through modulation of hormones such as leptin and ghrelin [16]. In the younger children it was observed that increased physical activity was associated with increased waist circumference. Increased physical activity, may not in fact translate to total energy expenditure being greater, since we did not measure the actual intensity of exercise physically (there could be variable amounts of time spent being still, even when 'playing games'. This may have been more marked in the unstructured games in the younger age group. Further, this was reported by the parent- there may have been errors in the reportage. To resolve this would need nested studies with measurements of physical activity. In addition to the behaviors, parental BMI, especially maternal BMI which is a known risk factor for childhood obesity [17] was a significant contributor to increased WC in the present study. This association likely reflects the clustering of risk behaviors in families and genetic factors that affect obesity. To our knowledge, no Indian study has previously examined the associations between parental overweight and WC in children and adolescents.

In conclusion, while the present study identified certain factors related to increased WC in urban Indian school children, it highlighted the necessity of structuring dietary intake questionnaires in such a way, that questions do not arouse the anxiety to report what is deemed to be 'healthy'. It also emphasizes capturing information on behaviors that are not campaigned as risk factors of obesity. The limitation of this cross sectional study was that while hypotheses could be generated, determinants




Children <7 years Children ≥10 years

**FIG.1** *Factors related to increasing waist circumference. The size of each bubble is proportional to the regression coefficient of the particular predictor. FF- Fast food, IFF- Indian Fast Food (Vada, Bhaji, Bonda), SD- Soft drinks, FJ- Fruit Juice, EO- eating out, C- Chocolates, SBF- Skip Breakfast, MBMI- Mother's BMI, FBMI - Father's BMI.*

of WC could not be ascertained and we also could not measure body fat or morbidity. Additionally, the questionnaires used in this study were not validated. These issues can be better evaluated by future longitudinal studies using validated questionnaires attributing lifestyle change to better measures of adiposity such as body fat.

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*Contributors*: RK conceived and designed the study, interpreted the data and wrote the manuscript. TT and SS conducted the statistical analysis. DPL, NRS and RJ collected the data and helped in drafting the manuscript. SB was involved in reviewing the results and manuscript. AVK was involved in the design of the study, interpretation of the data and revised the manuscript for important intellectual content. He will act as the guarantor of the study. The final manuscript was approved by all the authors.
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