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Utility of Body Mass Index and Abdominal Obesity Indices to Evaluate Overweight and Obesity in Tobagonian School Children

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Abstract

Globally, the prevalence of overweight and obesity in childhood is increasing. In the Caribbean, at least one in every five children carries unhealthy weight**,** and risks developing chronic diseases like diabetes in adulthood. In Trinidad and Tobago one in four, one in three, and 25% of school-aged children have been reported to be overweight or obese. This study examined the prevalence of overweight and obesity among 6 to 13 year-old Tobagonian school children utilizing body mass index (BMI) and other abdominal obesity indices, and described the relationships among them. Body weight, height and waist circumference (WC) were measured.

BMI, waist-to-height ratio (WHtR), and conicity index (Ci) were calculated. The school children's (N = 107) ages ranged from six to 13 years. The majority of boys (41.0%) and girls (37.0%) were 11 years old. Mean heights and weights ranged from 132.0±17.8 to 152.0±13.8 cm and 27.8±10.2 to 51.8±17.1 kg, respectively, for all children.

The mean BMI ranged from 17.7±3.2 to 21.3±4.7 kg/m^2. Girls had slightly higher mean values of WC than boys (70.6±13.4 versus 68±10.8 cm). For both genders, irrespective of age, the mean WHtR values ranged from 0.47±0.1 to 0.49±0.1. Ci values ranged between 1.1±0.2 to 1.2±0.1 for all children.

The children's BMI and WC values were strongly, positively correlated (r = 0.78, P<0.00001), while BMI and WHtR were moderately, positively correlated (r = 0.72, P<0.00001). There was an inverse relationship between BMI and Ci (r = -0.036) and a weak, positive correlation between WC and Ci (r = 0.038). Among the school children, there were 38 and 24% overweight and obesity, respectively, with strong linear relationships among BMI, WC and WHtR. The overweight and obesity seen in Tobago's primary school children requires introduction of early preventive and management strategies to reduce type 2 diabetes and other chronic disease risks.

Keywords: Overweight and obesity; Waist circumference, Waist-to-height ratio, Conicity index, Abdominal obesity indices

Introduction

Globally, the prevalence of overweight and obesity in childhood is increasing. In 2013, 42 million children around the world, under the age of five were overweight or obese [1]. Overweight and obesity, which were once considered a developed country problem, are now on the rise in developing countries [1]. In developing countries, the rate of increase in childhood overweight and obesity has been more than 30% higher than that of the developed countries [1]. The Caribbean Public Health Agency (Carpha) reported that at least one in every five children in the Caribbean region carries unhealthy weight, and risks developing chronic diseases like diabetes and cardiovascular ailments later in life [2]. Additionally, in the County of St. George and South Trinidad, Republic of Trinidad and Tobago, one in four and one in three children, respectively, have been reported to be overweight [3]. Older data have also shown that in Trinidad and Tobago, 25% of school-aged children (5 to 18years) were overweight or obese [4]. However, there is a scarcity of comprehensive research data on the weight status of children in Trinidad and Tobago.

Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health. Obesity in childhood is associated with a wide range of serious health complications including type 2 diabetes (T2D), cardiovascular disease (CVD) and some types of cancers such as endometrial, breast, and colon [1]. Childhood obesity is associated with premature death and disability in adulthood. In addition to increased future risks, obese children experience breathing difficulties, increased risk of fractures and other psychological effects [1]. Overweight and obesity, as well as their related diseases, are largely preventable. Body mass index (BMI) has been used as the "gold standard" to classify overweight and obesity and for identifying those at increased risk for adiposity-related adverse health outcomes [1]. BMI is defined as the ratio of an individual's weight to height squared (kg/m^2). However, BMI has potential limitations. Firstly, BMI does not distinguish between fat and fat-free mass [5-6]. Secondly, it measures excess weight relative to height, therefore failing to reflect excessive central (also known as abdominal, upper-body or visceral) fat distribution; and thirdly, the age-, gender-, and ethnic-specific standards of BMI are not feasible for non-professionals and parents [7]. To simplify, BMI measures overall fat or general obesity [8]. Cardio metabolic complications such as T2D are related to excessive central fat distribution rather than general obesity. Hence, a combination of anthropometric measurements of adiposity, which consider body fat distribution, such as waist circumference (WC), waist-to-height ratio (WHtR) and conicity index (Ci) have been developed and utilized in studies of childhood overweight and obesity [9]. WC, WHtR, and Ci identify the fat located in the central region of the body, that is, abdominal obesity [8].

WC represents the accumulation of abdominal and visceral fat and has been validated as one of the simplest and most valuable measure of visceral adipose tissue [6, 10]. WC is often used as a surrogate marker of abdominal fat mass, because it correlates with abdominal fat mass (subcutaneous and intra-abdominal). WC is associated with cardio metabolic disease risk, especially diabetes [11-13]. Researchers have demonstrated a strong link between having a large WC and an increased risk of developing T2D, independent of a person's BMI. In a recent study, Adegbija et al. [14]

observed that in T2D, the lowest and highest incidences were observed among persons in the lowest and highest WC quartiles, respectively. The WHtR has been reported as an alternative tool to determine central fat distribution and it is correlated to visceral fat [7]. Studies have reported that WHtR is strongly associated with CVD risk factors at early ages [5, 15]. Khoury and colleagues [5] reported that a significant proportion of obese children with increased WHtRs had abnormal cardio metabolic risk factor levels. The researchers concluded that WHtR should be included in the routine screening and assessment of overweight and obese children, and that those with an elevated WHtR should undergo further cardio metabolic risk assessment. Xu et al. [16] concluded that WHtR ≥ 0.5 may be the best indicator for undiagnosed T2D and impaired fasting glucose. The Ci, a function of weight, height and WC has been proposed as useful index of abdominal adiposity. Ci has been associated with increased mortality risk in a dialysis population [17]. The Ci is based on the volume estimate of the human body constructed to range between the shapes of a cylinder and a double cone assuming a constant body density [8]. For example, a Ci of 1.50 means that the individual's WC is 1.5 times bigger than the circumference of a hypothetical cylinder; the theoretically expected range is 1 to 1.73 [8]. The objective of the study was to examine the prevalence of overweight and obesity among 6 to 13 year-old school children utilizing BMI and other abdominal obesity indices (WC, WHtR and Ci). The relationships among the measures were also investigated.

Materials and Methods

Setting: The data were collected at the '*7th Annual Diabetes in the Limelight Jamboree*' hosted by the Bovell Cancer Diabetes Foundation (BCDF) at Roxborough, Tobago. BCDF is a charitable non-governmental organization (NGO) based in Tobago, Trinidad and Tobago. The Republic of Trinidad and Tobago is a twin-island state located in the Caribbean between the Caribbean Sea and the North Atlantic Ocean, northeast of Venezuela (Figure 1). The total area of Trinidad and Tobago is 5,128 km^2 with a population of 1.3 million [18]. There were 140,300 cases of diabetes in Trinidad and Tobago in 2015 [19] (Figure 2). Published data regarding the prevalence of diabetes, overweight and obesity among children in Trinidad and Tobago are scarce. Older data from 2008 indicated that more than 450 children in the country were diagnosed with type 1 diabetes [20].

Consent: The consent forms regarding participation in activities at the Jamboree were obtained from the parents through the schools. Demographic data including the school children's date of birth were collected.

Measurements: All measurements were performed in duplicate by trained, experienced evaluators. Anthropometric indices, body weight (BW), height (Ht) and WC were taken.

***BW*:** Children removed their shoes and any jackets. Weights were evaluated at the nearest 0.1 kg with electronic, portable scales. Children were instructed to stand on the scales with their weight distributed evenly between both feet.

Ht: Height was measured to the nearest 0.1 cm using portable stadiometers and as described by Bacopoulou et al. [21]. Briefly, the children's feet were placed together with heels, buttocks and shoulder blades against the stadiometer and the head was positioned in the Frankfurt horizontal plane.

WC: WC was measured to the nearest 0.1 cm with children standing erect, arms at the side, feet positioned close together and the abdomen relaxed. During measurements, the tape was positioned at a level parallel to the floor, and a horizontal measure was taken at the narrowest point of the torso above the umbilicus and below the rib cage [22].

Figure 1: Map of Trinidad and Tobago (www.graphicmaps.com)

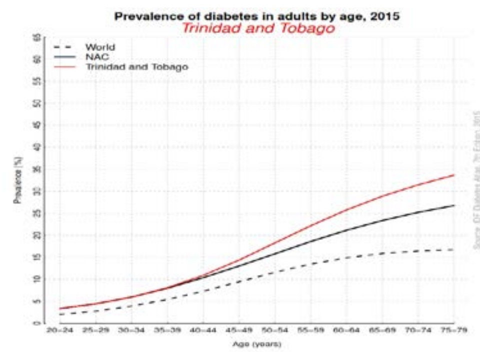


Figure 2: The dotted line is the distribution of diabetes prevalence by age for the world; the black line is the distribution for the region; and the country distribution is plotted in the red line [19].

***BMI*: BMI was calculated using the Centers for Disease Control (CDC) BMI Percentile Calculator for Child and Teen [23]. The calculator provides BMI and the corresponding BMI-for-age percentile on a CDC BMI-for-age growth chart and is used for children and teens, aged 2 through 20 years old.

WHtR: WHtR was calculated as the ratio of waist circumference (cm) / Height (cm).

Conicity index: the Ci was determined by measuring weight, height and waist circumference using the following mathematical equation [8]:

C index = Waist circumference (m)/ [0.109 X √ {Body weight (kg) / Height (cm)}] where 0.109 is a constant, which results from the conversion of units of volume and mass into units of length [24].

Statistical Analysis: Descriptive statistics (means, median, frequencies and standard deviations) were calculated for BMI, BW, Ht, WC, WHtR and Ci. BMI percentiles were calculated. Pearson's correlation coefficient was calculated to assess the relationships among BMI, WC, WHtR and Ci [25].

Results and Discussion

Participants' Characteristics

Roughly 250 primary school children from different villages in Tobago participated in the *"7th Annual Diabetes in the Limelight Jamboree"*. However, complete datasets for the anthropometric measures were obtained for 107 boys and girls, representing seven schools (Figure 3). Analysis of the characteristics of the children revealed that their ages ranged from six to 13 years (Table 1).

Figure 3: Map of Tobago showing the villages (www.mytobago.info). The villages that are highlighted in green indicate the location of the schools with complete datasets.

Males outnumbered the females (57.0 versus 43.0%). The majority of boys (41.0%) and girls (37.0%) were 11 years old. Six-year old had minimum presentation with one boy in that age category.

Table 1: Characteristics of the Participants in the Study (N = 107)

	Age (y)	Boys (%)	Girls (%)	Total (%)
	6	1 (1.6)	0 (0.0)	1 (1.6)
	7	5 (8.2)	1 (2.2)	6 (5.6)
	8	6 (9.8)	12 (26.1)	18 (16.8)
	9	4 (6.6)	2 (4.3)	6 (13.0)
	10	7 (11.5)	11 (23.9)	18 (16.8)
	11	25 (41.0)	17 (37.0)	42 (39.3)
	12	10 (16.4)	3 (6.5)	13 (12.1)
	13	3 (4.9)	0 (0.0)	3 (2.8)
Total		**61 (57.1%)**	**46 (42.9%)**	**107**

Heights and Weights

Means and standard deviations of height, weight, BMI, WC, WHtR and Ci for the children were calculated by schools (Table 2). It was observed that the tallest and heaviest children came from Roxborough A.C. Heights ranged from 132.0±17.8 to 152.0±13.8 cm. The mean weights for all children by schools ranged from 27.8±10.2 to 51.8±17.1 kg.

Body mass index (BMI)

The mean BMI ranged from 17.7±3.2 to 21.3±4.7 kg/m^2 (Table 2). In growing children BMI varies with age and gender. For example, a 5-year-old boy with a BMI of 20 kg/m^2 is likely to be overweight, but a 15-year-old boy with a BMI of 20 kg/m^{2}is likely to be lean.

Table 2: Mean ± SD for the Anthropometric Measurements by School

	Belle Garden AC	Pembroke AC	Goodwood Methodist	Mason Hall Gov't	Roxborough AC	Delaford AC	Delaford RC
Height (cm)	148.2±15.7	145.2±17.2	132.0±17.8	135.0±9.2	152.0±13.8	136±11.7	140±2.5
Weight (kg)	49.9±13.3	49.3±16.3	36.1±6.3	33.1±15.8	51.8±17.1	39.1±9.5	27.8±10.2

BMI (kg m^2)	21.3±4.7	21.3±6.3	20.8±4.9	17.8±6.6	21.1±6.1	17.7±3.2	17.9±5.2
WC (cm)	71.7±9.8	74.6±12.9	59.8±6.6	63.1±13.1	72.8±12.4	67.5±8.1	67.4±12.3
WHtR	0.47±0.06	0.49±0.1	0.45±0.03	0.47±0.1	0.48±0.1	0.49±0.1	0.48±0.1
Conicity index (m/√[kg/m])	1.2±0.1	1.2±0.1	1.1±0.2	1.2±0.1	1.2±0.1	1.2±0.1	1.2±0.1

SD – standard deviation; BMI – body mass index; WC –waist circumference; WHtR – waist-to-height ratio; AC – Anglican; RC – Roman Catholic; Gov't - Government

Therefore, for BMI to be meaningful in children, it must be compared to a reference-standard that accounts for the child's age and gender. Similarly, in terms of interpreting the percentiles, a 12-year-old girl at the 95th percentile has a higher BMI than 95 out of every hundred 12-year-old girls in the reference population. The weight status is then identified from the child's BMI-for-age percentile (Table 3).

Table 3: BMI (body mass index) -for-age weight status categories and the corresponding percentiles

BMI (body mass index) categories for children and adolescents	BMI-for-age and gender percentiles (ages 2-20)
Underweight	Less than the 5th percentile
Normal or Healthy Weight	5th percentile to the 85th percentile
Overweight	Equal to or greater than the 85th percentile
Obese	Equal to or greater than the 95th percentile

During the child development process, height, weight, bone mass and percent body fat change at different times and rates during the growth spurts [26]. Therefore, BMI results in children need to be interpreted cautiously [26]. For example, more mature girls have higher body fat levels than other girls [26]. According to Dinsdale et al. [27], children's BMI is classified using thresholds, which vary to take into account the child's age and gender. These thresholds are usually derived from a reference population, known as a child growth reference. They are calculated by weighing and measuring a large sample of children to illustrate how BMI varies in children of different ages and gender. These data show the pattern of growth, an average BMI for a boy or girl at a particular age, and the distribution of measurements above and below this value. This means that individual children can be compared to the reference population and the degree of variation from the expected value can be calculated. The BMI-for-age percentiles from the present study are shown in Table 4.

Four of the seven schools had children in the underweight category, that is, less than the 5th percentile (Table 4). Mason Hall Government and Delaford A.C. had the highest percentage of children in the normal weight category (Table 4). In terms of overweight and obesity, Goodwood Methodist school children had the highest percentage in this category with Delaford A.C. having the lowest (Tables 3 and 4). Goodwood Methodist and Mason Hall Government schools had the highest and lowest percentages of children, respectively, in the obese category (Table 4). Generally, BMI is most commonly used as an assessment tool for diagnosing overweight and obesity. However, although BMI reflects total body fat, it does not assess central adiposity, which is associated with metabolic risk factors [28]. In a study of Brazilian children, Beck et al. [29] reported BMIs ranging from 14.9 to 36.5 and 15.5 to 56.9 for boys and girls, respectively. For both boys and girls in the current study, BMIs ranged from 17.3 to 21.3. Overall, 38 and 24% of the children in the current study were overweight and obese, respectively. More girls were overweight and obese than boys (Figure 4).

Table 4. Summary of Children's BMI-for-Age Percentiles by School

Body mass index (BMI) Percentile

School	Number of participants	$<5^{th}\%$	$5^{th} – 85^{th}\%$	$\geq 85^{th}\%$	$>95^{th}\%$
Pembroke A.C.	24	0	63	38	33
Goodwood Methodist	9	0	44	56	44
Belle Garden A.C.	20	5	45	50	25
Mason Hall Gov't	16	6	69	25	6
Roxborough A.C.	16	19	38	44	38
Delaford A.C.	15	13	67	20	7
Delaford R.C.	7	0	57	43	14

Waist Circumference

The mean WC values by school are shown in Table 2. It was observed that girls had slightly higher mean values of WC than boys (70.6±13.4 versus 68±10.8 cm). The WC for the boys ranged from 51.8 to 95.3 cm. Kawatra et al. [30] tabulated age specific WC percentile charts for male and female children in a rural Indian population. Using Kawatra et al.'s [30] charts, most of the WC values for boys in the current study were in the 97^{th} percentile, regardless of age. In general, our WC values for the boys were also higher than the recommended ≥ 90th percentile criteria set by the International Diabetes Federation (IDF) for obesity in children 6 to 16 years [31].

A similar situation existed for the girls, WC ranged from 54.6 to 111.8 cm. Comparing them to IDF ≥ 90^{th} percentile criteria for obesity, and the ≥ 95^{th} percentile for rural Indian girls given by Kawatra et al. [30], generally the girls in the current study had higher WC values. On the other hand, the WC for boys and girls (range - 59.8±6.6 to 74.6±12.9 cm) were lower than the upper limit (range - 57.2 to 116.8 cm) reported by Beck et al. [29] for Brazilian children. When all the children from all schools were lumped together, irrespective of age or gender, the mean WC was 69.4±12.0 cm, with most students having WC values at 63.5 cm (9.4 frequency %). It should be noted that the girls attending Goodwood Methodist primary school were not calculated in these statistics because of the small number.

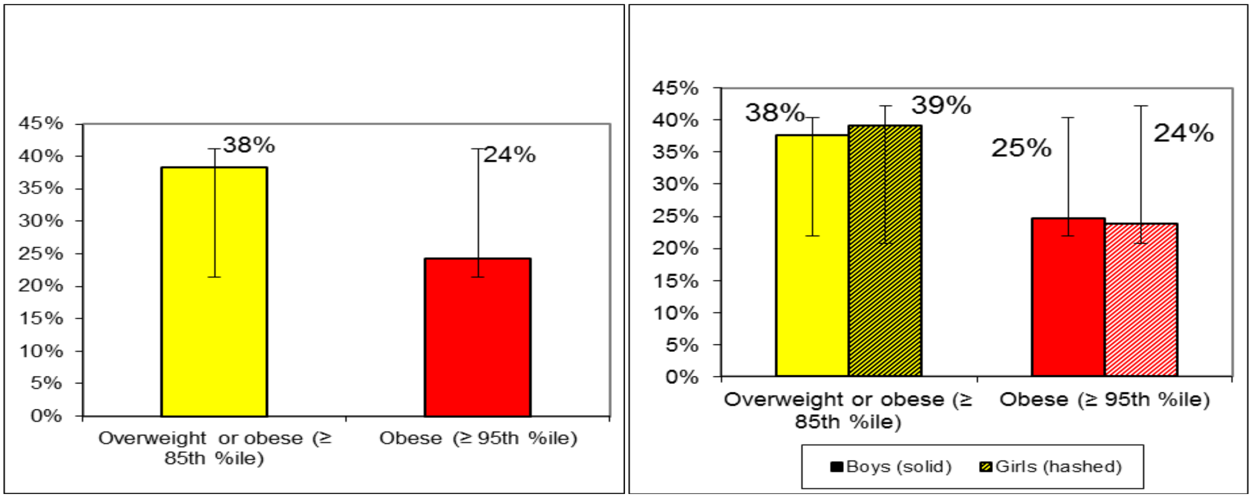


Figure 4: Prevalence of overweight and obesity, all children (N = 107); a) all children; b) by gender

It is well established that central fat distribution in children increases the risk of metabolic complications such as insulin resistance, glucose intolerance and high blood pressure [10]. It is also known that adiposity in childhood proceeds into adulthood. The WC is strongly correlated with metabolic risk factors [32]. According to the IDF and the National Cholesterol Education Program (NCEP), WC is an essential diagnostic criterion for metabolic syndrome [33, 34]. WC in children also has a good correlation with insulin resistance [32]. Bassali et al. [22] also reported that children with high waist circumference were about 27 times more likely to have high BMIs and roughly 3.7 times more likely to have high fasting insulin.

Waist to height ratio

The mean WHtR by schools is shown in Table 2. The mean values in the current study for both genders, irrespective of age ranged from 0.47±0.1 to 0.49±0.1. Kawatra et al. [30] created age specific WHtR charts for rural Indian boys and girls and considered the 95th percentile as the cutoff limit to identify obese children. The mean values of their 95th percentiles were 0.43 and 0.44 for boys and girls, respectively. The school children in the current study had mean values above those of Kawatra et al. [30]. The WHtR cutoffs according to the World Health Organization (WHO) criteria range from 0.47 to 0.50 and 0.46 to 0.50 among girls and boys, respectively. The school children in the present study had mean values slightly below the higher limits for WHO's WHtR criteria for both genders. It has been previously suggested that the cutoff of WHtR ≥ 0.5 is a useful predictor of central obesity across gender and ethnicity, from childhood to adulthood [21, 35-37]. All children in the present study had WHtR <0.5. Contrary to Kawatra et al.'s [30] 95th percentile values of 0.43 and 0.44, Bacopoulou et al. [21] observed that the WHtR cutoff point of 0.5 corresponded to the 85th to 95th percentiles at all ages for Greek boys and girls.

Kuriyan et al. [38] also developed age and gender-specific WHtR percentile values for urban south Indian children. Their findings revealed WHtR ranging from 0.52 to 0.56 in the 95th percentile for boys and girls, which was higher than the values in the current study. The WHtR values for the children in the current study would have been placed in the 75th and 85th percentiles of Kuriyan et al.'s [38] study. In a study of Brazilian adolescents, de Pádua Cintra et al. [39] reported that for females 10 to 15 years, the mean WHtR ranged from 0.44±0.05 to 0.45±0.05. Their maximum values ranged from 0.63 to 0.72.

The WHtR mean value range reported for males 10 to 15 years were 0.43±0.05 to 0.46±0.06, while the maximum values ranged from 0.62 to 0.83 [39]. Yan et al. [7] evaluated WHtR and obesity among Han and Uygur Chinese school children and set cutoff points of WHtR of 0.45 for both boys and girls; and 0.49 and 0.48 for boys and girls, respectively, in their study population. Beck et al. [29] reported WHtR ranging from 0.35 to 0.72 for Brazilian boys and girls; their upper limit was much higher than seen in the present study. Marrodán et al. [40] demonstrated that WHtR was an effective method to predict relative adiposity in children and adolescents aged six to 14 years. Brambilla et al. [41] observed that, when compared to WC and BMI, WHtR was the best predictor of adiposity in children and adolescents. In the current study, the children classified as overweight and obese based on BMI and WC were classified as normal weight using our measured data for WHtR and WHO's WHtR criteria (<0.5 vs ≥ 0.5).

Conicity index

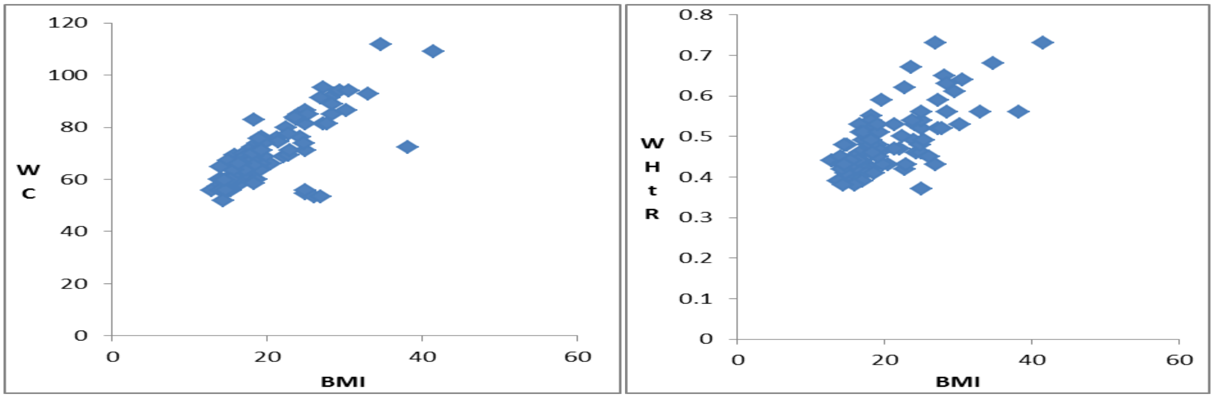
The mean conicity index by schools for all genders is shown in Table 2. Ci values ranged between 0.79±0.16 and 1.47±0.13 for all children. The mean Ci (1.18±0.1) among the Tobagonian school children was consistent with that reported in the literature, and also fell within the theoretically expected range of 1.0 to 1.73 expressed by Valdez [8]. Mungreiphy et al. [42] saw clear ethnic differences in Ci among South, North and North East Indians. In their study Ci ranged from 1.08 to 1.16 among males and females. Similarly, Perez et al. [43] reported conicity values ranging between 0.99 and 1.18 for boys and girls. Shankarappa et al. [44] reported mean Ci values of 1.2 for cases and control in a study among 94 Indian males with diabetes. The mean value for our children's Ci were within Shankarappa et al.'s [44] cut-off limit of 1.25.

Correlations among anthropometric measures

The children's BMI and WC scores were strongly, positively correlated indicating that the children who had high BMI scores also had high WC scores and vice versa (Figure 5). Our findings were consistent with those of Zhang et al. [45], who reported a strong, positive correlation between BMI and WC in Chinese women. Conversely, the strong correlation (Figure 5) seen in our study and Zhang et al.'s [45] was divergent to Musaad et al.'s [46] who reported a weaker, positive correlation (r = 0.59) between BMI and WC in five to 18 year-old children. BMI and WHtR scores showed a moderate, positive correlation (Figure 5). However, Zhang et al. [45] reported a strong correlation (r = 0.82) between BMI and WHtR in Chinese women. Our findings were consistent with those reported by Musaad et al. [46] who found that in children five to 18 years, BMI had a moderate, positive correlation with WHtR (r = 0.73).

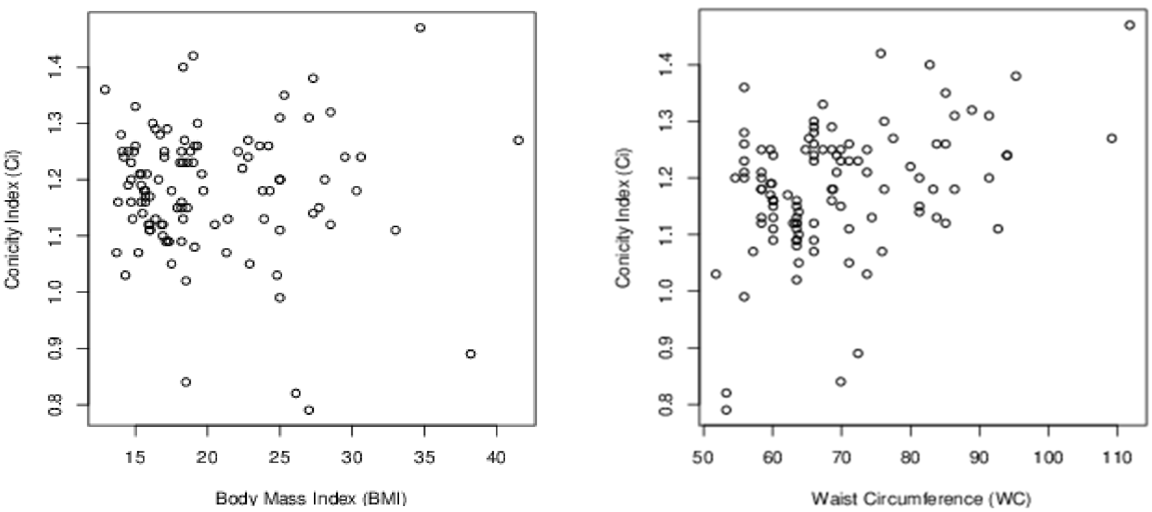
As shown in Figure 6, there was an inverse relationship between BMI and Ci. Zhang et al. [45], Musaad et al. [46] and Chakraborty and Bose [47] found weak, positive correlations (r=0.36, 0.36 and 0.32) between BMI and Ci in Chinese women, five to 18 year-old children and male slum dwellers in India, respectively. In a case-control study among 94 Indian males with diabetes, Shankarappa et al. [44] also reported a weak, positive correlation (r = 0.30) between BMI and Ci. A weak, positive correlation was seen between WC and Ci (Figure 6), which was consistent with the literature. However, the strength of the association between WHtR and Ci, although significant, was less than that for WC and Ci

Figure 7: WC was strongly, but not significantly associated with WHtR (Figure 7). Although Ci was found to be poorly correlated with BMI, WC and WHtR, the other measures had strong inter-correlations.



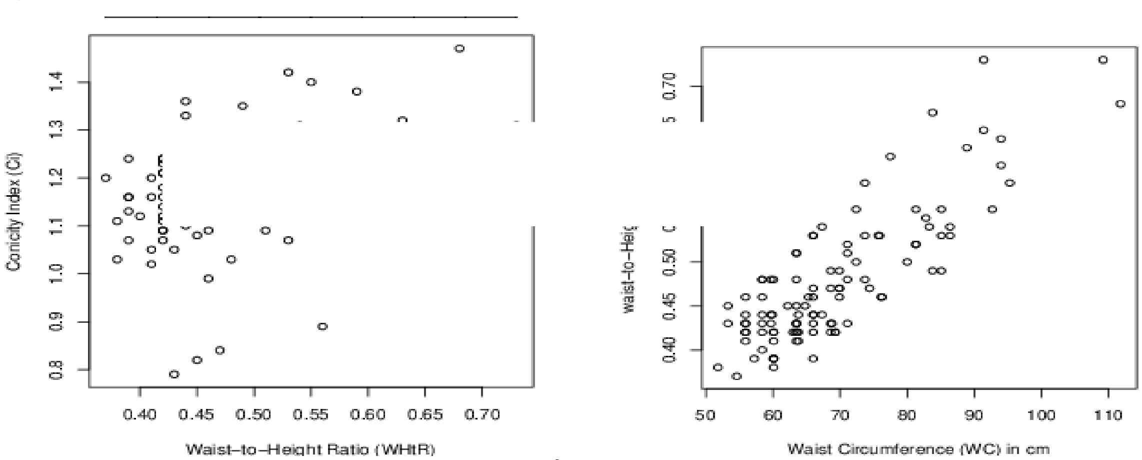
A. Correlation between BMI and WC (r = 0.78, P< 0.00001) B. Correlation between BMI and WHtR (r 0.72, P< 0.00001)

Figure 5: Correlations among BMI, WC and WHtR in the children. ***BMI –body mass index; WC – waist circumference; WHtR – waist-to-height ratio***



A. Correlation between BMI and WC (r = 0.78, P< 0.00001) B. Correlation between WC and Ci (r = 0.038)

Figure 6: A. Correlation between conicity index and body mass index; B. Waist circumference and conicity index



A. B.

A. Correlation between WHtR and Ci (r=0.83) B. Correlation between WHtR and WC (r=0.345, P<0.0003)

Figure 7. A. Correlation between WHtR (waist-to-height ratio and C (conicity index) Ci; B. WC (waist circumference) and WHtR

Strengths and Limitations

To the best of the authors' knowledge, no growth standards for children exist in Trinidad and Tobago. A single reference applicable to all children is still highly debatable [48]. It is generally recognized that the best reference should be derived from the growth pattern of the healthy population that will use it [48]. When international references are utilized, they should be validated where appropriate. This study utilized the reference population in the CDC-BMI-for-age percentile chart based on children in the United States of America (U.S.A). It is highly possible that the U.S.A. population hass different in growth characteristics to the children in our study. One positive is that the weight status of the children in the current study was determined by comparing their BMI to U.S.A children of the same age and gender. Using data based on gender and age when interpreting BMI account for the growth changes that they experience throughout childhood, and the differences in growth experienced by boys and girls.

The data collected were cross-sectional; it is preferable to use a series of measurements to diagnose weight status of children. However, four different indices were utilized. The sample size was small therefore the findings are not generalizable to the population of children in Tobago or elsewhere. However, groups of children from different schools were assessed; this could be potentially useful information to help determine which, and whether obesity-related interventions are appropriate for these schools. Moreover, the findings from this small study could be used to: i) create awareness among school and health personnel, community members, and policy makers about the extent of weight problems in the specific school subpopulations; ii) provide an impetus to improve policies, practices, and services to prevent and treat overweight and obesity among children; and iii) identify other subgroups of children at greatest risk for overweight and obesity.

It is important to note that the four indices used in the current study looked at different aspects of obesity. BMI measures excess weight relative to height, that is, overall fat or general obesity. Waist circumference represents the accumulation of abdominal and visceral fat, while waist-to-height ratio measures central fat distribution. The conicity index estimates the abdominal breadth with respect to the body's volume; it is the only abdominal measure that incorporates weight. Relying on BMI alone may conceal differences in central obesity. All the children were classified either as under-, normal-, over-weight or obese based on the indices used. The mean WHtR values classified the children as normal weight.

Given the burden of childhood obesity, our findings have public health relevance. Based on our data and previous reports, in addition to BMI, waist-related abdominal obesity measures should be incorporated as part of routine screening and assessment for childhood overweight and obesity. Decisions regarding the measures of adiposity to be used in screening and assessment of childhood obesity should include considerations regarding cost and feasibility, among other factors. For example, research determining disease etiology will need more precise measures, but measures for use in messages to promote public health could be less precise.

Conclusion

There was a prevalence of overweight (38%) and obesity (24%) among the school children. Increased WC in children is a standalone predictor of insensitivity to insulin [49]; while Ci has been linked with increased mortality risk in dialysis patients. The study also demonstrated strong linear relationships among BMI, WC and WHtR in perceived healthy school children. It is important to assess weight, not only on general adiposity (BMI), but also on abdominal fat, which is well known to be linked to many health risks, such as diabetes, impaired fasting glucose and cardiovascular diseases. It is also important to sensitize the schools and community members on regular weight assessment using BMI and a combination of other abdominal obesity parameters. More studies are needed to investigate whether the relationships seen in this study hold true for larger samples of children. Finally, the overweight and obesity seen in the study requires the introduction of early preventive and management strategies in Tobago's primary school children to reduce the risk of T2D and other chronic diseases. Until large-scale data are available, we suggest that BMI and the abdominal obesity measures used in this study be utilized as a "starting point" to measure overweight and obesity in Tobagonian and Trinidadian children.

Conflicts of Interest

There are no conflicts of interest, financial or otherwise

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