Obesity Pillars 5 (2023) 100053

Contents lists available at ScienceDirect

Obesity Pillars

journal homepage: www.journals.elsevier.com/obesity-pillars

Obesity, overweight and hyperglycemia among primary school children in a low-middle income country with a multiethnic population

Jerry R. Toelsie [a], Frederika Morpurgo [b], Ingrid Krishnadath [c], Robbert Bipat [a,*]

[a] Department of Physiology, Faculty of Medical Science, Anton de Kom University of Suriname, Paramaribo, Suriname
[b] Department of Pediatrics's, Lands Hospital, Paramaribo, Suriname
[c] Department of Public Health, Faculty of Medical Science, Anton de Kom University of Suriname, Paramaribo, Suriname

ARTICLE INFO

Keywords:
Obesity
Overweight
Children
Hyperglycemia
Ethnicity

ABSTRACT

Objective: The number of children with cardiovascular risk factors is increasing steadily. However, limited data are available on the prevalence of overweight, obesity, and hyperglycemia among children in low-middle-income countries with multiethnic populations. Therefore, we assessed these factors in a school-based survey in Suriname, a low-middle-income country.

Methods: We invited pupils of 5th and 6th grade visiting the primary school to participate in this survey. We used a questionnaire and face to face interviews, and conducted measurements to collect data on biological factors (ethnicity, sex, length, weight, waist circumference, and fasting blood glucose levels), behavior (frequency of physical activity, breakfast, bedtime, screentime), consumption (fruit and vegetables, snack, dairy products) and social factors (parental education, living area).

Results: Overall, the percentage of children with overweight was 13.9%, obesity 13.3% and for elevated fasting blood glucose level (> 6 mmol/L) 4.5%. In the investigated group of individuals, obesity and overweight were associated with sex (girls showed a lower OR of 0.54 [95%CI: 0.39–0.75] for obesity), ethnicity (Javanese 2.1, 1.5–3.0 for overweight and 5.0, 3.1–8.2 for obesity, Maroon 2.2, 1.2–4.1 and Mixed ethnicity 1.7, 1.1–2.6, for obesity compared to Hindustani), behavior (Skip Breakfast: 1.4, 1.2–1.7, physical activity: 0.8, 0.7–0.9) and maternal education level (high 1.7, 1.0–2.7). Children with elevated fasting blood glucose levels showed an association with obesity (1.8, 1.2–2.7) and waist circumference (1.02, 1.01–1.03).

Conclusion: The results show that there is a high prevalence for overweight, obesity and elevated fasting blood glucose among children in Suriname. Furthermore, during childhood ethnicity is associated with obesity and overweight. We suggest that the modifiable risk factors such as BMI, WC, behavior, consumption are interesting for early intervention in children in a developing country.

1. Introduction

Obesity, overweight and hyperglycemia, are interconnected and attribute to the risk of developing several non-communicable disorders such as diabetes [1–4]. Traditionally, middle aged and elderly individuals were primarily diagnosed with type 2 diabetes mellitus, whereas children suffered predominantly from type I diabetes mellitus [5]. However, the number of children with diabetes mellitus type II increased significantly over the past 4 decades [6–8]. For instance, children visiting primary school showed a tenfold increase and those visiting junior high school a doubling of the incidence of type 2 from 1974 to 1994 in Japan [9]. Shortly after that, the same trend followed in other developed Asian, European, and American countries [10–13]. Consequently, among the young people, this form of diabetes claims up to 80% of the newly diagnosed cases at present day [14–17].

Obesity allegedly plays an important role in the development of diabetes [18]. A study among children and young adults in the UK reported a fourfold greater risk of developing type 2 diabetes mellitus in individuals with obesity [19] while a German study showed that impaired glucose regulation was prevalent in more than 5% of a group of children with obesity [20]. Remarkably, the number of children with obesity shows a large variation among countries [21] and mainly shows an increase in developing countries [22,23]. In adults, a large body of evidence indicates that all these conditions are related to multiple factors

* Corresponding author. Department of Physiology, Faculty of Medical Science, Anton de Kom University of Suriname, Kernkampweg 5, Paramaribo, Suriname.
E-mail addresses: jerry.toelsie@uvs.edu (J.R. Toelsie), rika@sr.net (F. Morpurgo), Ingrid.krishnadath@uvs.edu (I. Krishnadath), robbert.bipat@uvs.edu (R. Bipat).

https://doi.org/10.1016/j.obpill.2022.100053
Received 2 November 2022; Received in revised form 6 December 2022; Accepted 22 December 2022

such as ethnicity, behavior, diet, and socio-economic factors. However, data of children regarding the prevalence of these risk factors in developing countries is lacking.

Children of ethnic minorities, compared to white children, showed a higher prevalence of obesity and type 2 diabetes in the USA [24,25]. Among the minority groups the prevalence of obesity varied from 12 to 30% [26], while compared with white young people between 10 and 19 years old they had an almost three-fold higher occurrence of Type 2 diabetes [27]. Another American study showed a great variation of physical activity among children/adolescents of various ethnicities, with especially Hispanic boys and Hispanic girls as well as girls of all ethnicities performing significantly less [28]. Other studies showed that behavior [29], diet [30] and socio-economic factors [31] also affect the number of children with obesity. However, until now, no study determined the prevalence of obesity, overweight, hyperglycemia, and the related factors among children of various ethnicities in lower middle-income countries. This makes it hard for public health authorities to introduce proper policies regarding the prevention and treatment of these disorders.

For this reason, we assessed the prevalence of hyperglycemia, overweight, obesity and the risk factors in a population of children residing in a multi-ethnic and multicultural population in a developing country. This was achieved through a cross-sectional school-based survey assessing biological, anthropometric, and behavioral risk factors among schoolchildren of the 5th and 6th grade of primary school.

2. Subjects and methods

2.1. Study area

Suriname, a former Dutch colony, located at the Northeast coast of South America, has about 550,000 inhabitants. Its multiethnic/multicultural population mainly consists of American Indians (descendants of the indigenous inhabitants), Maroons (descendants of the slaves fled into the interior), Creoles (descendants of the slaves living in the coastal area), Chinese (descendants of the immigrants from China), Hindustani (descendants of the immigrants from British India), Javanese (descendants of the immigrants of Indonesia) and Whites (descendants of the European colonists) as well as all possible mixes of all these major groups. The country is administratively divided into ten districts, including the capital Paramaribo where nearly half of the population lives.

2.2. Study design

We designed a school-based survey to collect data among the children. All primary schools in the districts Nickerie, Coronie, Saramacca, Para and Commewijne were included in this survey. In Paramaribo and Wanica primary schools were selected from several regions, because of the large number of schools. We invited pupils of the 5th and 6th grade of the primary school to participate and collected data from May 2013 to April 2016. Due to financial and infrastructural restrains, the three remaining districts were not included in this study.

We used trained staff to conduct face-to-face interviews with the children, send questionnaires to the parents/guardians and conducted measurements to collect data on biological, behavioral, consumptive, and social risk factors. *Biological factors* included sex (boys/girls), ethnicity (Hindustani, Creole, Javanese, Marron, Amerindian, Chinese, White, and Mixed), body mass index (BMI = weight(kg)/(Length(m)^2) and waist circumference (cm). We used the parent/guardian reported ethnicity for the pupils. Blood glucose levels were measured after a finger prick and only the results after an overnight fast of at least 8 h were included for statistical analysis. *Behavioral factors* included frequency of physical activity (PA) during a week (categorized as $<$ 3x/week and $\geq$ 3x/week), bedtime (up to 22:00 h and later than 22:00 h), screen time (time spent sitting before a game, video, or television categorized into $<$2 h/day and $\geq$2 h/day) and whether the children were used to skip breakfast. To assess patterns of c*onsumption* we collected data on the frequency of daily consumption of several products such as vegetable, fruit ($\leq$1x/day and $>$ 1x/day), dairy products (1x/day and $\geq$1x/day), and snacks ($<$1x/day and $\geq$ 1x day). *Social factors* included living area and education level of both parents. We considered the districts Wanica and Paramaribo as urban and the others as rural area. Parental education was categorized into low (education at the primary school level or lower), middle (education at secondary level) and high (education at the level of high school or higher). All questions were in Dutch, the official tongue, and all school children can communicate in this language. In case of haziness, the trained staff elaborated on the meaning of the questions.

2.3. Outcome

All fasting blood glucose (FBG) levels $\geq$6 mmol/L were categorized as elevated fasting blood glucose levels (EFBG) and we used the WHO criteria to classify diabetes and prediabetes. Overnight fasting blood glucose levels between 6 and 7 mmol/L were considered as prediabetes and $\geq$7 mmol/L as diabetes [32]. Type I diabetes was identified when diagnosis had already been established by the family physician or pediatrician as could be derived from the questionnaire. Children were classified as normal, overweight, or obese according to the WHO growth reference chart (BMI for children between 5 and 19 years) [33]. All participants with an adverse outcome were referred to their family physician.

2.4. Data processing

We applied the double entry verification method to locate and correct data-entry errors. Two separate groups of staff members entered collected data into two separate databases. Both databases were compared and mismatches were evaluated and corrected where necessary.

2.5. Statistical analysis

The subpopulation with a fasting blood glucose sample of at least 8 h was entered for the analysis of EFBG levels. The statistical analysis for BMI included children classified under normal, overweight, and obese categories. We assessed the distribution of risk factors overall and among the different ethnic groups. The Student t-test was used to determine significant differences between two groups and the ANOVA to compare means between more than two groups. Next, we assessed, with binominal and multi-nominal regression, the association between EFBG levels and BMI categories with the biological, behavior, consumption, and social factors. We used the statistical software program SPSS 22 for processing and P values $<$ 0.05 were considered as statistically significant different.

2.6. Permission

The Ministry of Health granted ethical approval (VG 009–2013) and the Ministry of Education endorsed this study (KBcp 384). The purpose of the study was explained, and the management of the schools granted permission for the participation of their school. The parents or legal guardians of the pupils gave informed consent for participation.

3. Results

In total 6146 pupils participated and 6144 completed this survey. Due to the small number of the ethnic groups the Whites (n = 4) and Chinese (n = 30), we excluded these group from further analysis. We also excluded a number of 315 children who did not appropriately report their ethnicity for the analysis's regarding ethnic differences. The pupils included in this study were from the districts Paramaribo (16.8%), Wanica (17.8%), Commewijne (18.9%), Nickerie (20.0%), Coronie (2.2%), Para (17.0%) and Saramacca (7.3%). The general characteristics as well as the distribution of the risk factors in the different ethnic groups are presented in Table 1.

3.1. Body Mass Index

The prevalence of overweight and obesity in boys was 13.0% and 14.8% and in girls 14.8% and 11.9%, respectively. The prevalence of these conditions among children were 13.5% and 14.7% in the urban area and 14.2% and 12.7% in the rural areas.

The results from Table 2 illustrate that the biological factors waist circumference correlated positively with overweight and obesity, and boys had higher odds for overweight and obesity. In addition, pupils from a Javanese ethnicity showed a higher odd for both overweight and obesity. The behavior factor skipping breakfast was positively associated with being overweight or obese, while frequent physical activity decreased the odds for both conditions. Peculiarly, daily vegetable consumption and the education level of the mother were positively related with the odds of developing obesity.

3.2. Elevated fasting blood glucose levels

We obtained 3716 fasting blood samples with a nearly equal distribution between both sexes (boys: 53.2% and girls: 46.8%). The overall prevalence of diabetes and prediabetes was 0.5% and 4%, respectively. Both categories were grouped into elevated EFBG in the following analysis. The mean FBG levels differed slightly among the ethnic groups, however the prevalence of EFBG was not significantly different among those groups. Furthermore, the mean FBG levels and the prevalence of EFBG were not significantly different between the sexes (FBG: boys: 5.0 [95%CI: 5.0–5.1] and girls: 4.9 [95%CI: 4.9–5.0] mmol/L, and EFBG: boys: 4.7% vs girls 4.3%). Children visiting the primary school in the rural area had a slightly higher FBG than children visiting the schools in the urban area (median: 5.1 [95%CI: 5.1–5.1] vs. 4.8 [95%CI: 4.7–4.8] mmol/L), yet the prevalence of EFBG did not differ significantly between these areas (rural area: 4.9% vs urban area: 3.8%).

In Table 3 the odds between EFBG levels with several risk factors are presented. It shows that waist circumference, overweight and obesity positively correlated with an elevated fasting blood glucose level. In contrast an inverse relation exists with the frequency of PA.

4. Discussion

This study is the first to assess the distribution of elevated blood glucose levels, overweight and obesity among primary school children in these six ethnic groups in a developing country. We evaluated the association of overweight/obesity or EFBG levels with biological factors, behavior, consumption, and social factors. We found that overweight, obesity, and waist circumference were positively, whereas frequency of PA was negatively correlated with EFBG levels. Ethnicity, female sex, skipping breakfast, lower frequency of PA, higher education level of the mother and high vegetable consumption were positively associated with overweight or obesity.

4.1. Overweight and obesity

The prevalence of overweight and obesity estimated in this study is lower than that of the USA [34] but higher than many European countries [35]. The results of these studies illustrate regional differences and emerge the need for regional/country specific interventions. Accordingly, other studies have also reported ethnic disparities among both children [26,36] and adults [37,38]. In the present study, we see a clear association of the Javanese ethnic group with obesity. Taking a look in Indonesia, where the ancestors of these children came from, we also observe a trend for high rates of obesity [39]. Moreover, differences in the odds of developing overweight or obesity have been reported at an age of as young as four years already [40]. All these studies suggest that ethnic specific intervention for overweight and obesity should start at an early stage of life.

The WHO PA recommendation for children incorporates duration, frequency as well as intensity. Previous studies have demonstrated that intensity and duration of physical activity are inversely related with overweight and obesity [41]. The results of the present study demonstrated that frequency of physical activity is inversely associated with overweight and obesity and suggest that a higher frequency of PA might be enough to combat overweight and obesity among children. However, more detailed investigation is needed.

Another behavior that was associated with overweight and obesity was skipping breakfast, which might involve insulin. It is reported that skipping breakfast is associated with a higher insulin resistance [42]. Insulin-resistant state is associated with impaired glucose transport and higher levels of insulin, however, the anti-lipolytic effect of insulin is relatively preserved which may maintain or expand adipose stores [43]. On the other hand, several other studies have described conflicting results [44–46] even if the energy intake and nutrient composition were considered [47]. Our results suggest that breakfast, a factor that can be controlled easily, needs to be explored in more detail.

Parental education is one of the strongest socio-economic factors that is associated with childhood obesity [48] and is mostly positively

Table 1
General characteristics and risk factors identified in participants.

	Hindustani (n = 1706)	Creole (n = 523)	Javanese (n = 899)	Maroon (n = 808)	Amer-indian (n = 196)	Mixed (n = 1663)	Overall (n = 5795)
Age (yrs) Median, [95%CI]	11.9 [11.8–12.0]	12.5 [12.4–12.6]	11.7 [11.6–11.8]	12.6 [12.5–12.7]	12.3 [12.1–12.5]	12.0 [11.9–12.0]	12.0 [12.0–12.1]
Girls (%)	52.5	53.0	47.2	56.7	44.9	50.9	51.6
Weight (kg) * Median, [95% CI]	42.3 [41.6–42.9]	46.8 [45.7–47.9]	42.3 [41.5–43.1]	44.3 [43.6–45.0]	43.9 [42.4–45.4]	43.2 [42.6–43.8]	43.2 [43.0–43.6]
Length (m) * Median, [95% CI]	1.50 [1.49–1.50]	1.56 [1.54–1.56]	1.47 [1.46–1.47]	1.53 [1.53–1.54]	1.49 [1.48–1.53]	1.51 [1.50–1.51]	1.50 [1.50–1.51]
BMI* Median, [95%CI]	18.6 [18.4–18.8]	19.2 [18.9–19.6]	19.4 [19.1–19.7]	18.7 [18.5–18.9]	19.5 [19.0–19.9]	18.9 [18.7–19.1]	18.9 [18.8–19.0]
Overweight (%)*	14.2	11.9	15.6	11.9	19.4	13.8	13.9
Obesity (%)*	15.3	10.7	18.6	5.9	7.7	13.5	13.3
WC (cm)* Median, [95%CI]	70.6 [70.0–71.2]	69.4 [68.5–70.3]	68.9 [68.2–69.7]	66.8 [66.2–67.3]	70.1 [68.7–71.4]	69.2 [68.7–69.7]	69.3 [69.0–69.7]
Samples for FBG (%)	64.9	51.0	77.9	60.1	66.2	63.1	64.5
FBG (mmol/L)* Median, [95%CI]	4.8 [4.8–4.9]	4.9 [4.8–5.0]	5.1 [5.0–5.1]	4.9 [4.8–4.9]	5.1 [5.0–5.2]	5.1 [5.0–5.1]	5.0 [4.9–5.01]
Diabetes (%)	0.2	0.8	0.4	0.2	0.0	0.9	0.5
Prediabetes (%)	4.0	3.4	4.2	2.9	3.9	4.6	4.0
EFBG levels (%)	4.2	4.1	4.6	3.1	3.9	5.5	4.5

BMI: Body Mass Index; WC: waist circumference; FBG: Fasting blood glucose; EFBG (%): Percentage children with elevated fasting blood glucose levels; *$p < 0.05$.

Table 2
Odd's ratios for biological, behavioral, and social factors regarding overweight and obesity.

	OVERWEIGHT			OBESITY		
	OR	95% CI for OR		OR	95% CI for OR	
		Lower	Upper		Lower	Upper
Biological factors						
Age	0.467*	0.426*	0.513*	0.229*	0.197	0.266
Waist circumference (cm)	1.321*	1.295	1.347	1.671*	1.621	1.724
Sex						
• *Girls (reference)*	1			1		
• *Boys*	1.582*	1.288	1.945	2.762*	2.019	3.777
Ethnicity						
• *Hindustani (reference)*	1			1		
• *Creole*	1.664*	1.112	2.489	4.295*	2.325	7.932
• *Javanese*	2.963*	2.128	4.126	8.852*	5.502	14.241
• *Maroon*	2.731*	1.926	3.871	10.088*	5.606	18.154
• *Amerindian*	2.058*	1.257	3.369	2.183	0.855	5.574
• *Mix*	1.689*	1.276	2.236	3.414*	2.273	5.128
Behavior						
Having breakfast (reference)	1					
Skip breakfast	1.244*	1.039	1.490	1.431*	1.194	1.715
PA < 3x/week (reference)	1					
PA ≥ 3x/week	0.806*	0.685	0.949	0.710 *	0.600	0.840
Screen time <2 h/day (reference)	1			1		
Screen time ≥2 h/day	1.032	0.877	1.213	0.939	0.795	1.109
Bedtime ≤22:00 h (reference)	1					
Bedtime >22:00 h	0.908	0.752	1.096	0.875	0.719	1.065
Frequency of consumption						
No daily consumption of vegetables (reference)	1			1		
Daily consumption of vegetables	1.037	0.882	1.218	1.361*	1.155	1.603
Fruit consumption ≤ 1x/d (reference)	1					
Fruit consumption ≥ 1x/d	0.958	0.804	1.142	0.967	0.809	1.156
Dairy products < 1x/d (reference)	1					
Dairy product ≥ 1x/d	0.969	0.821	1.143	0.908	0.767	1.076
Snacks ≤ 1x/d (reference)	1					
Snack > 1x/d	1.003	0.851	1.181	0.909	0.768	1.077
Social factors						
Living in rural area	1			1		
Living in urban area	0.878	0.702	1.098	0.987	0.792	1.230
Level of education of mother						
• *Low (reference)*	1			1		
• *Middle*	1.197	0.925	1.549	1.371*	1.058	1.776
• *High*	1.533	0.974	2.411	1.398	0.869	2.249
Level of education of father						
• *Low (reference)*	1			1		
• *Middle*	1.118	0.871	1.434	0.845	0.663	1.077
• *High*	1.009	0.603	1.686	0.640	0.373	1.097

1 Adjusted for age and sex; BMI= Body Mass Index, *p < 0.05.

associated with obesity in low-income countries in contrast to high income countries [49]. A previous study reported that higher education and income are associated with excessive food intake in adults and adolescence [50]. In the present study, the odds for developing obesity tend to increase with a higher education level of the mother while they tend to decrease with the education level of the father. However, only the mid-level of education was significantly different. A more detailed assessment is needed to assess parenteral influences especially the maternal involvement. Differences between maternal and paternal education are also reported in several studies which are probably a consequence of cultural and/or regional differences [51,52].

A previous study has demonstrated excessive food consumption among adults [53]. In the present study we found a positive association with daily vegetable consumption among children with obesity. We have collected data only on the frequency of consumption of several products and no data was available on the total amount and total energy intake. It might be that daily consumption of vegetable might be associated with higher intake of food and calories. We suggest assessing diet in children in more detail in the near future.

4.2. Elevated fasting blood glucose levels

The prevalence of EFBG among children found in this study, is comparable with the prevalence reported in children and adolescents in Saudi Arabia [54] but is higher than the prevalence among children in the USA [55,56] and in China [57,58]. A study among children of comparable age in India showed that around 5.3% of the children had an elevated random blood glucose and that there also was a positive correlation with BMI [59]. The fact that among children suffering from overweight and obesity in China, the prevalence of Type 2 diabetes and pre-diabetes was 0.28% and 3.30%, respectively [60], while the prevalence among young adults was only 0.07% in a population study in the USA [61], only highlight that our findings among the total population is on the high end. These studies also illustrate differences between countries on the prevalence of diabetes mellitus among children while several studies among adults have demonstrated ethnic differences in the prevalence of diabetes mellitus as well [62,63]. The association between EFBG, BMI and PA combined with the absence of a significant difference between the descendants from different ethnic groups hints more to the assumption that

Table 3
Odd's ratios for biological, behavioral, and social factors with respect to elevated fasting blood glucose.

	OR	95% CI for OR	
		Lower	Upper
Biological factors			
Waist circumference (cm)	1.017*	1.005	1.030
Sex			
• Girls (reference)	1		
• Boys	1.056	0.7712	1.445
Ethnicity			
• Hindustani (reference)	1		
• Creole	0.991	0.502	1.956
• Javanese	1.158	0.728	1.843
• Maroon	0.771	0.421	1.413
• Amerindian	0.933	0.363	2.399
• Mix	1.368	0.917	2.041
BMI			
- Normal (reference)	1		
- Overweight	1.551*	1.006	2.392
- Obesity	1.763*	1.162	2.673
Age	1.050	0.935	1.181
Behavior[a]			
Having breakfast (reference)	1		
Skip breakfast	0.869	0.605	1.249
PA < 3x/week (reference)	1		
PA ≥ 3x/week	0.710*	0.510	0.988
Screen time <2 h/day (reference)	1		
Screen time ≥2 h/day	1.056	0.765	1.458
Bedtime ≤22:00 h (reference)	1		
Bedtime >22:00 h	0.954	0.654	1.393
Frequency of consumption[a]			
No daily consumption of vegetables	1		
Daily consumption of vegetables	0.972	0.700	1.348
Fruit consumption ≤ 1x/d (reference)	1		
Fruit consumption > 1x/d	1.093	0.773	1.543
Dairy products < 1x/d (reference)	1		
Dairy product ≥ 1x/d	0.774	0.551	1.088
Snacks < 1x/d (reference)	1		
Snack ≥ 1x/d	1.329	0.962	1.836
Social factors[a]			
Living in rural area (reference)	1		
Living in urban area	0.730	0.471	1.133
Level of education of father			
• Low (reference)	1		
• Middle	0.929	0.592	1.457
• High	0.528	0.148	1.876
Level of education of mother			
• Low (reference)	1		
• Middle	0.814	0.509	1.302
• High	1.415	0.589	3.400

[a] Adjusted for age and sex; BMI= Body Mass Index, *$p < 0.05$.

behavioral factors may play a more substantial role than the presumed genetic factors [64,65]. However, this has to be investigated in more detail, especially since a previous study among adults of the same ethnic groups as in this study, demonstrated that the prevalence of diabetes was significantly different among the various ethnic groups [66]. Of note, changes to non-modifiable factors as hormonal changes during growth/puberty may also contribute.

Another consideration is that we only found 3 pupils suffering from type 1 diabetes. This is not in line with international incidence and prevalence numbers of the disorder. In both developed and underdeveloped countries type 1 diabetes is the more prevalent form of diabetes in the studied age group [67–69]. We did not find any plausible explanation for this, but it surely requests further in detail studying of this phenomenon.

In the present study, waist circumference, which is usually considered as a parameter for central obesity, was associated with EFBG levels, overweight and obesity. Other studies also demonstrated that WC is correlated with BMI [70] and with diabetes among adults [66]. So far, we found no studies that have demonstrated that WC is correlated to EFBG levels in children and there are no guidelines for the interpretation of waist circumference in children. Notwithstanding this, the results of the present study suggest that waist circumference might be useful in the assessment of the risk for diabetes. A detailed exploration of this association is surely warranted, since only recently cut off points for WC among children have been established [71,72].

4.3. Limitations

This study did not involve all ten districts of Suriname. Due to financial restrains, we were able to only cover seven districts of Suriname. A possible bias could be expected, since the population in those three districts are predominantly of Maroon or Amerindian origin and their culture and habits regarding daily life activities differ from their counterparts living in the other districts. Roughly estimated only about 12–13% of children live there. However, additional studies in these districts must be performed to obtain a complete picture of the country. Furthermore, we used a finger prick to assess blood glucose levels to avoid more invasive procedure, such as vein puncture, in children. Another point of consideration is that we could obtain only about 60% of FBG, due to the time strain and children were not able to keep fasting. This problem can be overcome in future research with more staff and equipment that will allow more parallel measurements in a shorter time period. Finally, we do not have a comparable ethnic group for the Chinese and Whites to make good assessments regarding ethnicity.

5. Conclusion

This study demonstrates that hyperglycemia, obesity, and overweight are present among children of all the evaluated ethnic groups. These conditions are affected by non-modifiable factors as sex, ethnicity and modifiable factors as behavior and social factors. With this report we provide useful data to develop intervention and we suggest that these interventions should start during childhood to reduce noncommunicable diseases in the future. Frequency of PA as a preventive factor and waist circumference as a predictive parameter in children and influences of parental education need to be explored in more detail.

Contribution of authors

JT and FM designed the study. IK processed the data and JT drafted the manuscript. RB finalized the manuscript. All authors critically analyzed data, reviewed, and approved the final manuscript and take full responsibility for the content of the manuscript.

Funding statement

The study was financially supported by:
The Staatsolie foundation, Suriname.
Soroptimist International Club (Netherland).

Research ethics and patient consent

The Ministry of Health granted ethical approval (VG 009–2013) and the Ministry of Education endorsed this study (KBcp 384). The purpose of the study was explained, and the management of the schools granted permission for the participation of their school. The parents/guardians of the pupils gave informed consent for participation. All procedures have been carried out in accordance with the declaration of Helsinki.

Data availability

Data are available from the authors on reasonable request.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Frederika Morpurgo reports financial support was provided by The Staatsolie foundation (Suriname). Frederika Morpurgo reports financial support was provided by Soroptimist International Club (Netherlands).

Acknowledgments

The authors of this manuscript like to express their gratitude to all collaborators and especially to dr. Ronald Assen, the Ministry of Health, Ministry of Education, Science and Culture, Faculty of Medical Sciences, Bureau voor Openbare Gezondheidszorg, Prof R. Hirasingh, L. Berggraaf, Soroptimist International Club (Paramaribo), C. Rommy, Medical Students, MyLab, involved medical doctors, directors of schools, teachers, parents/caretakers, and the pupils.

List of abbreviations

BMI	Body Mass Index
PA	Physical activity
WC	Waist circumference

References

[1] Rodgers A. Blood glucose and risk of cardiovascular disease in the Asia Pacific region. Diabetes Care 2004;27:2836–42. https://doi.org/10.2337/diacare.27.12.2836.

[2] Chobot A, Górowska-Kowolik K, Sokołowska M, Jarosz-Chobot P. Obesity and diabetes—not only a simple link between two epidemics. Diabetes Metab Res Rev 2018;34:1–9. https://doi.org/10.1002/dmrr.3042.

[3] Tong H Van, Luu NK, Son HA, Hoan N Van, Hung TT, Velavan TP, et al. Adiponectin and pro-inflammatory cytokines are modulated in Vietnamese patients with type 2 diabetes mellitus. J Diabetes Investig 2017;8:295–305. https://doi.org/10.1111/jdi.12579.

[4] Davidson JA, Parkin CG. Is hyperglycemia a causal factor in cardiovascular disease? Does proving this relationship really matter? Yes. Diabetes Care 2009;32:S331–3. https://doi.org/10.2337/dc09-s333.

[5] Reinehr T. Type 2 diabetes mellitus in children and adolescents. World J Diabetes 2013;4:270–81. https://doi.org/10.4239/wjd.v4.i6.270.

[6] Arslanian S. Type 2 diabetes in children: clinical aspects and risk factors. Horm Res 2002;57:19–28.

[7] Candler TP, Mahmoud O, Lynn RM, Majbar AA, Barrett TG, Shield JPH. Continuing rise of Type 2 diabetes incidence in children and young people in the UK. Diabet Med 2018;35:737–44. https://doi.org/10.1111/dme.13609.

[8] Reinehr T. Type 2 diabetes mellitus in children and adolescents. World J Diabetes 2013;4:270–81. https://doi.org/10.4239/wjd.v4.i6.270.

[9] Kitagawa T, Owada M, Urakami T, Yamauchi K. Increased incidence of non-insulin dependent diabetes mellitus among Japanese schoolchildren correlates with an increased intake of animal protein and fat. Clin Pediatr (Phila) 1998;37:111–5. https://doi.org/10.1177/000992289803700208.

[10] Panamonta O, Thamsiri N, Panamonta M. Prevalence of type II diabetes and metabolic syndrome among overweight school children in Khon Kaen, Thailand. J Med Assoc Thail 2010;93:56–60.

[11] Ramachandran A. Trends in prevalence of diabetes in Asian countries. World J Diabetes 2012;3:110. https://doi.org/10.4239/wjd.v3.i6.110.

[12] Dabelea D, Mayer-Davis EJ, Saydah S, Imperatore G, Linder B, Divers J, et al. Prevalence of type 1 and type 2 diabetes among children and adolescents from 2001 to 2009. JAMA 2014;311:1778–86. https://doi.org/10.1001/jama.2014.3201.

[13] Wabitsch M, Hauner H, Hertrampf M, Muche R, Hay B, Mayer H, et al. Type II diabetes mellitus and impaired glucose regulation in Caucasian children and adolescents with obesity living in Germany. Int J Obes 2004;28:307–13. https://doi.org/10.1038/sj.ijo.0802555.

[14] D'Adamo E, Caprio S, Rosenbloom AL, Silverstein JH, Amemiya S, Zeitler P, et al. Type 2 diabetes in youth: epidemiology and pathophysiology. Diabetes Care 2011;34:17–32. https://doi.org/10.2337/dc11-s212.

[15] Unnikrishnan R, Shah VN, Mohan V. Challenges in diagnosis and management of diabetes in the young. Clin Diabetes Endocrinol 2016;2:1–9. https://doi.org/10.1186/S40842-016-0036-6.

[16] Corbin LJ, Richmond RC, Wade KH, Burgess S, Bowden J, Smith GD, et al. Body mass index as a modifiable risk factor for type 2 diabetes: refining and understanding causal estimates using Mendelian randomisation. Diabetes 2016;65:3002. https://doi.org/10.2337/DB16-0418.

[17] Ciba I, Warnakulasuriya LS, Adikaram AVN, Bergsten P, Dahlbom M, Fernando MMA, et al. Prevalence of different states of glucose intolerance in Sri Lankan children and adolescents with obesity and its relation to other comorbidities. Pediatr Diabetes 2021;22:168–81. https://doi.org/10.1111/PEDI.13145.

[18] Chobot A, Górowska-Kowolik K, Sokołowska M, Jarosz-Chobot P. Obesity and diabetes—not only a simple link between two epidemics. Diabetes Metab Res Rev 2018;34:1–9. https://doi.org/10.1002/dmrr.3042.

[19] Abbasi A, Juszczyk D, van Jaarsveld CHM, Gulliford MC. Body mass index and incident type 1 and type 2 diabetes in children and young adults: a retrospective cohort study. J Endocr Soc 2017;1:524–37. https://doi.org/10.1210/js.2017-00044.

[20] Wabitsch M, Hauner H, Hertrampf M, Muche R, Hay B, Mayer H, et al. Type II diabetes mellitus and impaired glucose regulation in Caucasian children and adolescents with obesity living in Germany. Int J Obes 2004;28:307–13. https://doi.org/10.1038/sj.ijo.0802555.

[21] Spinelli A, Buoncristiano M, Kovacs VA, Yngve A, Spiroski I, Obreja G, et al. Prevalence of severe obesity among primary school children in 21 European countries. Obes Facts 2019;12:244–58. https://doi.org/10.1159/000500436.

[22] Poskitt EME. Childhood obesity in low- and middle-income countries. Paediatr Int Child Health 2014;34:239–49. https://doi.org/10.1179/2046905514Y.0000000147.

[23] Bentham J, Di Cesare M, Bilano V, Bixby H, Zhou B, Stevens GA, et al. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. Lancet 2017;390:2627–42. https://doi.org/10.1016/S0140-6736(17)32129-3.

[24] Isong IA, Rao SR, Bind MA, Avendaño M, Kawachi I, Richmond TK. Racial and ethnic disparities in early childhood obesity. Pediatrics 2018;141:1. https://doi.org/10.1542/peds.2017-0865.

[25] Dabelea D, Bell R, D'Agostino R, Imperatore G, Johansen J, Linder B, et al. Incidence of diabetes in youth in the United States. JAMA 2007;297:2716–24. https://doi.org/10.1001/jama.297.24.2716.

[26] Isong IA, Rao SR, Bind MA, Avendaño M, Kawachi I, Richmond TK. Racial and ethnic disparities in early childhood obesity. Pediatrics 2018;141:1. https://doi.org/10.1542/peds.2017-0865.

[27] Dabelea D, Bell R, D'Agostino R, Imperatore G, Johansen J, Linder B, et al. Incidence of diabetes in youth in the United States. JAMA 2007;297:2716–24. https://doi.org/10.1001/jama.297.24.2716.

[28] Armstrong S, Wong CA, Perrin E, Page S, Sibley L, Skinner A. Association of physical activity with income, race/ethnicity, and sex among adolescents and young adults in the United States findings from the national health and nutrition examination survey, 2007-2016. JAMA Pediatr 2018;172:732–40. https://doi.org/10.1001/jamapediatrics.2018.1273.

[29] Hong I, Coker-Bolt P, Anderson KR, Lee D, Velozo CA. Relationship between physical activity and overweight and obesity in children: findings from the 2012 national health and nutrition examination survey national youth fitness survey. Am J Occup Ther 2016;70. https://doi.org/10.5014/ajot.2016.021212. 7005180060pp.1–8.

[30] Al-Domi HA, Faqih A, Jaradat Z, AL-Dalaeen A, Jaradat S, Amarneh B. Physical activity, sedentary behaviors and dietary patterns as risk factors of obesity among Jordanian schoolchildren. Diabetes Metabol Syndr: Clin Res Rev 2019;13:189–94. https://doi.org/10.1016/J.DSX.2018.08.033.

[31] Wang Y, Lim H. The global childhood obesity epidemic and the association between socio-economic status and childhood obesity. Int Rev Psychiatr 2012;24:176–88. https://doi.org/10.3109/09540261.2012.688195.

[32] World Health Organization. Definition and diagnosis of diabetes mellitus and intermediate hyperglycaemia: report of a WHO/IDF consultation. 2006.

[33] BMI-for-age (5-19 years) n.d. https://www.who.int/tools/growth-reference-data-for-5to19-years/indicators/bmi-for-age (accessed December 1, 2022).

[34] Hales CM, Carroll MD, Fryar CD, Ogden CL. Prevalence of obesity among adults and youth: United States, 2015-2016 key findings data from the national health and nutrition examination survey. 2017.

[35] Spinelli A, Buoncristiano M, Kovacs VA, Yngve A, Spiroski I, Obreja G, et al. Prevalence of severe obesity among primary school children in 21 European countries. Obes Facts 2019;12:244–58. https://doi.org/10.1159/000500436.

[36] Karlsen S, Morris S, Kinra S, Vallejo-Torres L, Viner RM. Ethnic variations in overweight and obesity among children over time: findings from analyses of the Health Surveys for England 1998-2009. Pediatr Obes 2014;9:186–96. https://doi.org/10.1111/j.2047-6310.2013.00159.x.

[37] Krishnadath ISK, Toelsie JR, Nahar-van Venrooij L, Hofman A, Jaddoe VWV. Ethnic and sex-specific cut-off values for adult obesity in the Suriname Health Study. Obes Res Clin Pract 2016. https://doi.org/10.1016/j.orcp.2016.09.011.

[38] Snijder MB, Galenkamp H, Prins M, Derks EM, Peters RJG, Zwinderman AH, et al. Cohort profile: the healthy life in an urban setting (HELIUS) study in amsterdam, The Netherlands. BMJ Open 2017;7. https://doi.org/10.1136/bmjopen-2017-017873.

[39] Rachmi CN, Li M, Baur LA. Overweight and obesity in Indonesia: prevalence and risk factors—a literature review. Publ Health 2017;147:20–9.

[40] de Wilde JA, van Dommelen P, Middelkoop BJC, Verkerk PH. Trends in overweight and obesity prevalence in Dutch, Turkish, Moroccan and Surinamese South Asian children in The Netherlands. Arch Dis Child 2009;94:795–800. https://doi.org/10.1136/adc.2009.163709.

[41] Tarp J, Child A, White T, Westgate K, Bugge A, Grøntved A, et al. Physical activity intensity, bout-duration, and cardiometabolic risk markers in children and adolescents. Int J Obes 2018;42:1639–50. https://doi.org/10.1038/s41366-018-0152-8.

[42] Joo HJ, Kim GR, Park EC, Jang SI. Association between frequency of breakfast consumption and insulin resistance using triglyceride-glucose index: a cross-

sectional study of the Korea national health and nutrition examination survey (2016–2018). Int J Environ Res Publ Health 2020;17. https://doi.org/10.3390/ijerph17093322.
[43] Kahn BB, Flier JS. Obesity and insulin resistance. J Clin Invest 2000;106:473–81. https://doi.org/10.1172/JCI10842.
[44] Donin AS, Nightingale CM, Owen CG, Rudnicka AR, Perkin MR, Jebb SA, et al. Regular breakfast consumption and type 2 diabetes risk markers in 9- to 10-year-old children in the child heart and health study in england (chase): a cross-sectional analysis. PLoS Med 2014;11. https://doi.org/10.1371/journal.pmed.1001703.
[45] Monzani A, Ricotti R, Caputo M, Solito A, Archero F, Bellone S, et al. A systematic review of the association of skipping breakfast with weight and cardiometabolic risk factors in children and adolescents. What should we better investigate in the future? Nutrients 2019;11. https://doi.org/10.3390/nu11020387.
[46] Polonsky HM, Bauer KW, Fisher JO, Davey A, Sherman S, Abel ML, et al. Effect of a breakfast in the classroom initiative on obesity in urban school-aged children: a cluster randomized clinical trial. JAMA Pediatr 2019;173:326–33. https://doi.org/10.1001/jamapediatrics.2018.5531.
[47] Rosato V, Edefonti V, Parpinel M, Milani GP, Mazzocchi A, Decarli A, et al. Energy contribution and nutrient composition of breakfast and their relations to overweight in free-living individuals: a systematic review. Adv Nutr 2016;7:455–65. https://doi.org/10.3945/an.115.009548.
[48] Lamerz A, Kuepper-Nybelen J, Wehle C, Bruning N, Trost-Brinkhues G, Brenner H, et al. Social class, parental education, and obesity prevalence in a study of six-year-old children in Germany. Int J Obes 2005;29:373–80. https://doi.org/10.1038/sj.ijo.0802914.
[49] Muthuri SK, Onywera VO, Tremblay MS, Broyles ST, Chaput JP, Fogelholm M, et al. Relationships between parental education and overweight with childhood overweight and physical activity in 9-11 year old children: results from a 12-country study. PLoS One 2016;11. https://doi.org/10.1371/journal.pone.0147746.
[50] Nahar-van Venrooij LMW, Marhe E, Antonius-Smits C, Krishnadath IS. Adequate and excessive food consumption in Suriname: a multiethnic middle-income country. Int J Publ Health 2018;63:1059–69. https://doi.org/10.1007/s00038-018-1148-9.
[51] Feng Y, Ding L, Tang X, Wang Y, Zhou C. Association between maternal education and school-age children weight status: a study from the China health nutrition survey, 2011. Int J Environ Res Publ Health 2019;16. https://doi.org/10.3390/ijerph16142543.
[52] Muthuri SK, Onywera VO, Tremblay MS, Broyles ST, Chaput JP, Fogelholm M, et al. Relationships between parental education and overweight with childhood overweight and physical activity in 9-11 year old children: results from a 12-country study. PLoS One 2016;11. https://doi.org/10.1371/journal.pone.0147746.
[53] Nahar-van Venrooij LMW, Marhe E, Antonius-Smits C, Krishnadath IS. Adequate and excessive food consumption in Suriname: a multiethnic middle-income country. Int J Publ Health 2018;63:1059–69. https://doi.org/10.1007/s00038-018-1148-9.
[54] Al-Rubeaan K. National surveillance for type 1, type 2 diabetes and prediabetes among children and adolescents: a population-based study (SAUDI-DM). J Epidemiol Community Health 1978;69:1045–51. https://doi.org/10.1136/jech-2015-205710. 2015.
[55] Hamman RF, Bell RA, Dabelea D, D'Agostino RB, Dolan L, Imperatore G, et al. The SEARCH for diabetes in youth study: rationale, findings, and future directions. Diabetes Care 2014;37:3336–44. https://doi.org/10.2337/dc14-0574.
[56] Dabelea D, Mayer-Davis EJ, Saydah S, Imperatore G, Linder B, Divers J, et al. Prevalence of type 1 and type 2 diabetes among children and adolescents from 2001 to 2009. JAMA 2014;311:1778–86. https://doi.org/10.1001/jama.2014.3201.
[57] Dong G-H, Wang D, Liu M-M, Liu Y-Q, Zhao Y, Yang M, et al. Sex difference of the prevalence and risk factors associated with prehypertension among urban Chinese adults from 33 communities of China. J Hypertens 2012;30:485–91. https://doi.org/10.1097/HJH.0b013e32834f9dd3.
[58] Wang Z, Zou Z, Wang H, Jing J, Luo J, Zhang X, et al. Prevalence and risk factors of impaired fasting glucose and diabetes among Chinese children and adolescents: a national observational study. Br J Nutr 2018;120:813–9. https://doi.org/10.1017/S0007114518002040.
[59] Khadilkar AV, Lohiya N, Mistry S, Chiplonkar S, Khadilkar V, Kajale N, et al. Random blood glucose concentrations and their association with body mass index in Indian school children. Indian J Endocrinol Metab 2019;23:529. https://doi.org/10.4103/IJEM.IJEM_536_19.
[60] Zhu H, Zhang X, Li M-Z, Xie J, Yang X-L. Prevalence of Type 2 diabetes and pre-diabetes among overweight or obese children in Tianjin, China. Diabet Med 2013;30:1457–65. https://doi.org/10.1111/DME.12269.
[61] Lawrence JM, Divers J, Isom S, Saydah S, Imperatore G, Pihoker C, et al. Trends in prevalence of type 1 and type 2 diabetes in children and adolescents in the US, 2001-2017. JAMA 2021;326:717–27. https://doi.org/10.1001/JAMA.2021.11165.
[62] Nr B, Ig van V, G M, F H, Jb H, Bp M, et al. Prevalence of diabetes mellitus and the performance of a risk score among Hindustani Surinamese, African Surinamese and ethnic Dutch: a cross-sectional population-based study. BMC Publ Health 2008;8. https://doi.org/10.1186/1471-2458-8-271.
[63] Yj C, Am K, Mrg A, Sh S, Hs K, Ew G, et al. Prevalence of diabetes by race and ethnicity in the United States, 2011-2016. JAMA 2019;322:2389–98. https://doi.org/10.1001/JAMA.2019.19365.
[64] Khera Av, Chaffin M, Wade KH, Zahid S, Brancale J, Xia R, et al. Polygenic prediction of weight and obesity trajectories from birth to adulthood. Cell 2019;177:587–96. https://doi.org/10.1016/J.CELL.2019.03.028. e9.
[65] Riveros-McKay F, Mistry V, Bounds R, Hendricks A, Keogh JM, Thomas H, et al. Genetic architecture of human thinness compared to severe obesity. PLoS Genet 2019;15:e1007603. https://doi.org/10.1371/JOURNAL.PGEN.1007603.
[66] Krishnadath ISK, Nahar-van Venrooij LM, Jaddoe VWV, Toelsie JR. Ethnic differences in prediabetes and diabetes in the Suriname Health Study. BMJ Open Diabetes Res Care 2016;4:e000186. https://doi.org/10.1136/bmjdrc-2015-000186.
[67] Mayer-Davis EJ, Lawrence JM, Dabelea D, Divers J, Isom S, Dolan L, et al. Incidence trends of type 1 and type 2 diabetes among youths, 2002–2012. N Engl J Med 2017;376:1419–29.
[68] Group DP. Incidence and trends of childhood Type 1 diabetes worldwide 1990–1999. Diabet Med 2006;23:857–66.
[69] Patterson CC, Karuranga S, Salpea P, Saeedi P, Dahlquist G, Soltesz G, et al. Worldwide estimates of incidence, prevalence and mortality of type 1 diabetes in children and adolescents: results from the International Diabetes Federation Diabetes Atlas. Diabetes Res Clin Pract 2019;157:107842.
[70] Pettitt DJ, Talton JW, Liese AD, Liu LL, Crimmins N, West NA, et al. Comparison of two waist circumference measurement protocols: the SEARCH for diabetes in youth study. Pediatr Obes 2012;7:e81. https://doi.org/10.1111/j.2047-6310.2012.00088.x. –5.
[71] Bravo J, Raimundo AM, Santos DA, Timón R, Sardinha LB. Abdominal obesity in adolescents: development of age-specific waist circumference cut-offs linked to adult IDF criteria. Am J Hum Biol 2017;29:e23036. https://doi.org/10.1002/AJHB.23036.
[72] Hasegawa T, Inokuchi M, Matsuo N, Takayama JI. Population-based waist circumference reference values in Japanese children (0-6 years): comparisons with Dutch, Swedish and Turkish preschool children. J Pediatr Endocrinol Metab 2021;34:349–56. https://doi.org/10.1515/JPEM-2020-0418/MACHINEREADABLECITATION/RIS.