Cardiometabolic risk among Saudi children and adolescents: Saudi children's overweight, obesity, and lifestyles (S.Ch.O.O.Ls) study

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BACKGROUND AND OBJECTIVES: Diabetes and atherosclerotic cardiovascular disease are major contributors to the global burden of disease, with a high reported prevalence of risk factors among different populations. Early and efficient assessment of cardiometabolic risk is important to identify target groups for preventive interventions. The aims of Saudi children's overweight, obesity, and lifestyles study were to estimate the prevalence of the metabolic syndrome and to compare the different paradigms of assessing such risk among children and adolescents. The study was funded by National Guard Health Affairs and approved by the ethics committee.

DESIGN AND SETTINGS: A cross-sectional study of students from primary, middle, and secondary schools located in the residential areas for the Saudi National Guard employees in Riyadh.

METHODS: A random sample of 2149 students, clustered by school and stratified by grade, was selected from a sampling frame of 16 812 students from 10 schools in the residential areas for Saudi National Guard employees. Informed consent was taken from children and parents. Blood pressure, height, weight, waist circumference, and hip circumference were documented. Fasting blood samples were taken for blood glucose and lipid profile.

RESULTS: The prevalence of metabolic syndrome ranged from 2% to 18%, according to the sensitivity of the 6 different definitions. Systolic blood pressure and triglycerides-to-HDL (high-density lipoprotein) ratio showed a dose–response increase with the quartiles of waist circumference and body mass index (BMI). Assessment of cardiometabolic risk by diagnosing the metabolic syndrome would lead to missed opportunity of intervention in 94% to 95% of children identified to be in need of intervention by waist circumference and BMI above 75th percentile.

CONCLUSION: Relying on the diagnosis of the metabolic syndrome can harm primary preventive initiatives. BMI and waist circumference for age should be used for assessing cardiometabolic risk in children and adolescents.

Although clustering of adiposity, hyperglycemia, hypertension, and hyperuricemia was noticed in the early and mid-20th century,[1,2] the relationship of increased risk of atherosclerotic disease and diabetes with hyperinsulinemia and central adiposity was reported later.[3-5] The term "cardiometabolic risk" was introduced in 2006 by the American Diabetes Association.[6,7]

The current concept of cardiometabolic risk took off with syndrome X in 1988, later termed insulin resistance syndrome,[4,8] suggesting a possible role of insulin resistance in the etiology of hypertension, type 2 diabetes, and coronary artery disease (CAD).[9] It was an effort at explaining the pathophysiology of the clustering rather than introducing a diagnostic entity.[10,11]

World Health Organization introduced diagnostic criteria for the metabolic syndrome in 1998,[12] United States adult treatment panel III (ATPIII) in 2001,[13] and International Diabetes Federation (IDF) in 2005.[14] The IDF highlighted central adiposity as the sine qua non of the syndrome,[15-17] a decision retracted later in 2009.[18]

From 2003-2005, the prevalence of the syndrome was studied among children and adolescents by various authors, using different cutoff values for the component abnormalities,[19-23] while the IDF guidelines were released in 2007.[24]

Over the last decade, several studies reported a pandemic of the metabolic syndrome[25] the world over. Other than confirming the ubiquity of the problem, these studies proved to be of little use in therapeutic or preventive terms.[10]

Interventions suggested for increased cardiometabolic risk, other than pharmacotherapy in some instances,[26] have always included healthier lifestyles and dietary choices.[4,9,27] The role of these measures is well known in the etiology and prevention of type 2 diabetes and CAD.[28-30]

Such simple, benign, and effective interventions need to be applied widely, and the assessment for their application should be based on the simplest possible clinical indicators to ensure the efficiency of preventive initiatives.

On the contrary, a look at the various definitions of the metabolic syndrome among children (**Table 1**), it is apparent that some of these criteria would make the diagnosis unnecessarily specific,[16,19-24] leading to a loss of opportunity for simple preventive interventions. Irrespective of the outcome of the current debate about the very existence of this syndrome,[10,11,31] this should be reason enough to advocate an explicit de-emphasizing of the need for such diagnosis in primary care.

Lifestyles depend on individual and cultural world views, the molding and alignment of which starts in the early childhood. Efforts aimed at lifestyle change will conceivably be more effective and will have a lasting effect if initiated during the formative years. The study of prevalence and covariates of cardiometabolic risk among children and adolescents is, therefore, of pivotal importance.

The study is especially relevant to locales with an increasing projected prevalence of diabetes and cardiovascular disease, like the Middle East, where the prevalence of behavioral risk factors for these disorders is well known.[32] In Saudi Arabia, the increasing prevalence of overweight and obesity,[33] dyslipidemia,[34] hypertension,[35] diabetes,[36] and the metabolic syndrome has been reported both among adults[37] and children.[38]

The aims of Saudi children's overweight, obesity, and lifestyles (S.Ch.O.O.Ls) study were to estimate the prevalence of the metabolic syndrome and to compare the usefulness of clinical morphometric measurements in assessing cardiometabolic risk in children and adolescents.

METHODS

S.Ch.O.O.Ls study was a cross-sectional study of students from primary, middle, and secondary schools located in the residential areas for the Saudi National Guard employees in Riyadh. The study was approved by the Institutional Board of Review and Ethics Committee and was funded by National Guard Health Affairs.

A sample of 2149 out of 16 812 students from 10 schools was selected in 2 stages, clustered by schools and stratified by grade, with subsamples proportional to stratum-specific populations. Assuming a 50% prevalence of the metabolic syndrome, this sample size would estimate the true proportion within a 5% margin of error with more than 90% power at the 5% significance level.[39,40]

Informed consent was taken from children and parents at least two weeks before the data and blood sample collection. Medical history, information about the child's diet and lifestyle, and the family's socioeconomic information were filled in by the parents.

A health care team visited schools to examine the overnight fasting children. Height, weight, waist and hip circumference, and blood pressure were measured by registered nurses from the health care team. Blood samples were collected for glucose, total cholesterol, low-density lipoprotein cholesterol (LDL-c), high-density lipoprotein cholesterol (HDL-c), and triglycerides.

Children with known type 1 diabetes, hypertension, and those on any medication that might poten-

Table 1. Prevalence of metabolic syndrome according to its various definitions.

Definition	Prevalence	95% Confidence Interval
de Ferranti et al Circulation, 2004; 110, 2494-97	17.5%	14.5 %-21.1%
Ford et al Diabetes Care, 2005; 28, 871-81	4.9%	3.7%-6.5%
Cook et al. Arch Pediatr Adolesc Med, 2003; 157, 821-7	4.9%	3.7%-6.5%
Weiss et al[a] N Engl J Med, 2004; 350, 2362-74	0.5%	0.3%-1.0%
Cruz et al[a] J Clin Endocrinol Metab, 2004; 89, 108-13	1.6%	1.1%-2.2%
Alberti, G.; Zimmet et al "The IDF consensus definition of metabolic syndrome in children and adolescents," available at http://www.idf.org/	2.0%	1.4%-2.7%

IDF: International diabetes federation.

[a]Partial criteria, based on 4 out of 5 indicators, with missing impaired d glucose tolerance. Included only for comparison to IDF criterion.

Table 2. Summary of anthropometric and physiological measurements (Mean [SD] and Median [mad]) by age and gender.

Age group (n, %)	6–8 Y 518 (24.1)			9–11 Y 721 (33.6)		
Gender (n, %)	Male 268 (51.7)	Female 250 (48.3)	P	Male 383 (53.1)	Female 338 (46.9)	P
Weight (kg)	24.7 (7.1) (23 [4.4])	25.6 (7.2) (24 [5.9])	.657	35.5 (10.8) (33 [8.9])	38.2 (13.1) (35 [10.4])	.306
Height (cm)	125.8 (7.7) (128 [5.9])	124.6 (7.6) (124 [8.9])	.679	140.3 (8.3) (140 [8.9])	140.8 (8.9) (140 [8.9])	.847
BMI (kg/m²)	15.5 (3.6) (15 [2.3])	16.3 (3.2) (15.4 [1.9])	.222	17.8 (4.2) (16.9 [3.4])	19.0 (5.4) (17.8 [3.8])	.122
Waist (cm)	56.6 (7) (55 [5.9])	61.2 (7.2) (60 [5.9])	.003[a]	63.7 (9.9) (61 [8.9])	70.8 (9.6) (69 [8.9])	.002[a]
Hip (cm)	65.1 (6.9) (64 [5.9])	69.3 (7.6) (68 [5.9])	.027[a]	74.8 (9.8) (74 [10.4])	80.2 (11.4) (79 [10.4])	.016[a]
Waist-hip ratio	0.87 (0.06) (0.9 [0.07])	0.88 (0.04) (0.9 [0.04])	.252	0.85 (0.06) (0.84 [0.07])	0.89 (0.11) (0.88 [0.04])	.076
Waist-height ratio	0.45 (0.05) (0.4 [0.05])	0.49 (0.05) (0.5 [0.04])	<.001[a]	0.45 (0.06) (0.44 [0.06])	0.50±0.06 (0.50±0.05)	<.001[a]
Systolic blood pressure	107 (12) (106 [14])	105 (12) (106 [12])	.508	112 (14) (112 [13])	114 (13) (115 [12])	.531
Diastolic blood pressure	69 (9) (68 [7])	70 (9) (70 [12])	.469	69 (9) (69 [9])	74 (9) (73 [10])	.018[a]

Age group (n, %)	12–14 Y 609 (28.3)			15–17 Y 301 (14.0)		
Gender (n, %)	Male 334 (54.8)	Female 275 (45.2)	P	Male 153 (50.8)	Female 148 (49.2)	P
Weight (kg)	50.3 (16.2) (47 [13.3])	51.2 (12.6) (49 [11.9])	.824	63.3 (18.2) (59 [14.8])	55.6 (12.6) (53 [10.4])	.054
Height (cm)	156.7 (9.6) (157 [10.4])	152.6 (8.4) (153 [5.9])	.306	167.1 (5.4) (167 [5.9])	156.5 (6.9) (157 [5.9])	<.001[a]
BMI (kg/m²)	20.2 (5.2) (18.7 [4.0])	22.0 (5.5) (20.8 [4.4])	.102	22.6 (6.1) (21.3 [5.0])	22.6 (4.6) (21.5 [4.0])	.961
Waist (cm)	72.8 (12.1) (70 [8.9])	75.5 (9.3) (74 [8.9])	.129	77.9 (13.8) (74 [10.4])	74.4 (8.7) (74 [8.9])	.029[a]
Hip (cm)	84.4 (11.9) (82 [10.4])	90.7 (10.6) (89 [8.9])	.108	95.2 (13.2) (93 [10.4])	92.7 (9.6) (92 [7.4])	.332
Waist-hip ratio	0.86 (0.06) (0.86 [0.06])	0.83 (0.04) (0.83 [0.04])	.148	0.82 (0.08) (0.80 [0.06])	0.80 (0.04) (0.80 [0.04])	.388
Waist-height ratio	0.46 (0.07) (0.45 [0.05])	0.50 (0.06) (0.48 [0.06])	.006[a]	0.47 (0.08) (0.44 [0.06])	0.48 (0.05) (0.47 [0.05])	.119
Systolic blood pressure	120 (14) (120 [15])	110 (15) (110 [15])	.013[a]	130 (14) (130 [13])	118 (12) (119 [13])	<.001[a]
Diastolic blood pressure	72 (9) (72 [8])	72 (10) (71 [12])	.491	77 (9) (78 [9])	76 (9) (76 [8])	.040[a]

[a]Statistically significant differences.

tially alter the parameters of interest were excluded.

Double data entry and cross-validation were used to ensure accuracy.[41] R version 2.1.3 and Stata Intercooled version 13 were used for analysis.[40,42]

Complex survey design variables were set for analysis, with school as primary sampling unit and grade as stratification variable, and sampling weight based on sample and population sizes. Because of the high sampling fraction (12.8%), the finite population correction factor was used.

Means (standard deviations) and medians (median absolute deviations [MAD]) were reported as summary measures for continuous variables. Proportions of categorical variables were reported as percentages with 95% confidence intervals. Two group comparisons regarding continuous and categorical variables were done using estimation commands according to survey data analysis routines; chi-square tests were used for comparing multiple groups and trends. Pearson product–moment correlation coefficient was used for assessing correlations between continuous variables, and *z*-test was used to assess the significance of difference between correlation coefficients.[43] All tests of significance were 2-tailed at a 5% significance level.

RESULTS

The sample consisted of 1138 (53%) male and 1011 (47%) female students, ranging in age from 6 to 17 years. The summary of morphometric and physiological measurements is presented in **Table 2**.

A reversal of cardiometabolic risk profile between genders was observed starting the 12th year of age, the transformation becoming more apparent starting the 15th year of age. Females tended to reduce the values of cardiometabolic risk-related variables, previously higher than males, in favor of a healthier profile. Males, however, tended to increase the values of all risk-related variables after the 12th year of age.

Females had a higher triglycerides-to-HDL ratio before the 12th year of age (P=.041 for 6-8 years of age and .030 for 9-11 years), after which they reduced it compared to males. Similarly they had larger waists before the 12th year of age (P=.003 and .004) and larger waist-to-height ratios before the 15th year of age (P values< .001 for ages 6-11 years, and .006 for 12-15 years). Starting the 15th year, females not only reduced waists and waist-to-height ratios but also significantly increased HDL-c (P=.004).

Males had a higher systolic blood pressure starting the 12th year of age (P=.013 for 12–14 years and <.001 for 15–17 years). Diastolic blood pressure became higher for males starting the 15th year of life (P=.040).

This was accompanied by larger waists (*P*=.029 for 15–17 years), higher (albeit nonsignificantly) weights (*P*=.054), higher triglycerides-to-HDL ratio (*P*=.049 for 12–14 years, .018 for 15–17 years), higher triglycerides (*P*=.025 for ages 15 years and above), and higher fasting blood glucose (*P*=.007 for 12–14 years, nonsignificantly higher for 15–17 years) (**Table 3**).

Either systolic or diastolic, blood pressure was above 90th percentile45 in 52% students (47%–56%)—males having significantly higher systolic blood pressure than females for ages above 11 years (*P*=.026) and higher diastolic blood pressure above 15 years (*P*=.040).

While 29% (95% CI: 26%-31%) children were either obese (15%, 95% CI: 13%-17%) or overweight (14%, 95% CI: 12%–16%), 12% (95% CI: 10%–16%) of these children were underweight—majority (74%, 95% CI: 56%–86%) males and below 11 years of age (**Table 4**).

Thirty-one per cent children (95% CI: 27%–36%), including 14% (95% CI: 11%–19%) of those with normal weight, had waist circumference above 75th percentile.

The mean of the triglycerides-to-HDL-c ratio was 0.63 (0.4), with a significant trend of increasing values with increasing ages (chi-square for trend test=39.7, *P*<.001).

The mean of body mass index (BMI) was 19.1 (5.3) kg/m2 and that of waist circumference, 68.3 (12.0) cm. Both waist circumference and BMI above 75th percentile, after accounting for age, gender, and activity level, significantly predicted higher triglycerides, i.e., >1.1 mmol/L; triglycerides-to-HDL ratios >75th percentile (*P*<.001); and lower HDL-c, i.e., <10th percentile (*P*=.002).

Blood pressure >90th percentile and triglycerides-to-HDL ratio >75th percentile showed a significant linear trend of increasing with increasing quartiles of BMI and waist circumference (chi-square for trend test: from 59–150, all *P* values<.001).

The correlation of both waist circumference (r= .37) and waist-to-height ratio (r=.30) with triglyceride-to-HDL ratio was significantly higher (*z* values 11.2 and 8.6, respectively, *P*<.001) than that of waist-to-hip ratio (r=.04).

One-fifth (95% CI: 14%–27%) of the children did not undertake any sports activity at all due to the lack of motivation (30%, 95% CI: 20%-42%), and nonavailability of time or space (21% each, 95% CI: 13%–32%). After adjusting for age and gender, daily sports activity significantly predicted a lower prevalence of obesity (odds ratio 0.5, *P*<.001), but not of overweight (odds ratio .9, *P*=.373).

Obesity decreased in a linear fashion with increas-

Table 3. Summary of biochemical markers of cardiometabolic risk (Mean [SD] and (Median (mad)] by age and gender. All results are in mmol/L..

Age group (n, %)	6 to 8 Y 518 (24.1)			9–11 Y 721 (33.6)			12–14 Y 609 (28.3)			15–17 Y 301 (14.0)		
Gender (n, %)	Male 268 (51.7)	Female 250 (48.3)	*P*	Male 383 (53.1)	Female 338 (46.9)	*P*	Male 334 (54.8)	Female 275 (45.2)	*P*	Male 153 (50.8)	Female 148 (49.2)	*P*
Total cholesterol	3.95 (0.76) (3.98 [0.71])	4.37 (0.84) (4.28 [0.64])	.001[a]	4.14 (0.67) (4.1 [0.61])	4.15 (1.12) (4.13 [0.67])	.860	3.90 (0.69) (3.88 [0.60])	4.01 (0.71) (4.01 [0.59])	.197	3.84 (1.13) (3.69 [0.62])	4.06 (0.64) (4.02 [0.59])	.032[a]
HDL cholesterol	1.33 (0.29) (1.33 [0.25])	1.39 (0.27) (1.37 [0.28])	.145	1.36 (0.27) (1.32 [0.27])	1.34 (0.29) (1.33 [0.24])	.641	1.24 (0.24) (1.19 [0.24])	1.27 (0.25) (1.28 [0.25])	.429	1.13 (0.18) (1.13 [0.18])	1.33 (0.24) (1.30 [0.22])	.004[a]
LDL cholesterol	2.34 (0.63) (2.3 [0.55])	2.66 (0.79) (2.58 [0.54])	.001[a]	2.44 (0.60) (2.41 [0.55])	2.46 (0.98) (2.42 [0.57])	.798	2.29 (0.59) (2.24 [0.53])	2.40 (0.61) (2.39 [0.55])	.039[a]	2.30 (1.04) (2.16 [0.55])	2.38 (0.56) (2.33 [0.50])	.089
Triglycerides	0.62 (0.34) (0.56 [0.22])	0.76 (0.36) (0.66 [0.22])	.003[a]	0.71 (0.35) (0.62 [0.25])	0.81 (0.38) (0.72 [0.25])	.009[a]	0.79 (0.40) (0.70 [0.28])	0.78 (0.28) (0.74 [0.24])	.418	0.95 (0.50) (0.81 [0.33])	0.74 (0.29) (0.66 [0.19])	.025[a]
Fasting blood glucose	4.27 (0.56) (4.30 [0.44])	4.29 (0.40) (4.3 [0.30])	.823	4.55 (0.41) (4.6 [0.44])	4.50 (0.67) (4.5 [0.44])	.608	4.62 (0.42) (4.60 [0.30])	4.54 (0.65) (4.6 [0.44])	.007[a]	4.71 (0.48) (4.7 [0.44])	4.50 (0.57) (4.5 [0.44])	.215
Triglycerides to HDL-c ratio	0.50 (0.30) (0.42 [0.19])	0.58 (0.36) (0.46 [0.22])	.041[a]	0.57 (0.39) (0.47 [0.24])	0.65 (0.38) (0.55 [0.24])	.030[a]	0.68 (0.44) (0.59 [0.26])	0.65 (0.32) (0.59 [0.26])	.049[a]	0.89 (0.56) (0.74 [0.39])	0.58 (0.30) (0.50 [0.21])	.018[a]
HDL-c to LDL-c ratio	0.60 (0.24) (0.57 [0.16])	0.56 (0.18) (0.54 [0.15])	.025[a]	0.59 (0.21) (0.56 [0.18])	.59 (0.21) (0.56 [0.17])	.830	0.58 (0.21) (0.54 [0.18])	0.56 (0.16) (0.55 [0.15])	.203	0.54 (0.17) (0.51 [0.18])	0.59 (0.19) (0.57 [0.15])	.027[a]

SD: Standard deviation, HDL: high-density lipoprotein, LDL: low-density lipoprotein, HDL-c: high-density lipoprotein cholesterol, LDL-c: low-density lipoprotein cholesterol. [a]Statistically significant differences.

Table 4. Weight status as assessed with BMI-for-age measurement.[a]

Weight status	Definition: BMI-for-age percentile	Overall prevalence	95% Confidence interval	Prevalence among males	Prevalence among females	*P*
Obese	≥95th	14.8%	13.0%–16.8%	14.2%	15.5%	.546
Overweight	≥85th and <95th	13.8%	11.7%–16.1%	12.1%	15.7%	.058
Normal	Between 5th and 85th	58.9%	56.1%–61.6%	56.1%	62.0%	.031[b]
Underweight	Below 5th	12.5%	9.6%–6.2%	17.6%	6.9%	.002[b]

BMI: Body mass index.

[a]Ogden C, Flegal KM. "Changes in terminology for childhood overweight and obesity." Natl Health Stat Report 2010 Jun;25(25):1-5.

[b]Statistically significant differences.

Table 5. Prevalence of individual components according to the most sensitive definition of the metabolic syndrome; by de Ferranti et al.[21]

Component	Cutoff	Overall Prevalence	95% Confidence Interval	Prevalence among Males	Prevalence among Females	*P*
Blood pressure	>90th percentile	51.5%	47.0%– 56.0%	49.4%	53.9%	.265
HDL-c	<1.3 mmol/L	51.1%	47.0%–55.1%	55.0%	46.7%	.081
Waist circumference	>75th percentile	31.4%	27.3%– 35.9%	23.8%	40.0%	<.001[a]
Triglycerides	≥1.1 mmol/L	13.6%	11.4%–16.1%	13.0%	14.2%	.539
Fasting blood glucose	≥6.1 mmol/L	0.6%	0.4%–1.0%	0.4%	0.9%	.103

HDL-c: high-density lipoprotein cholesterol.

[a]Statistically significant differences.

ing weekly frequency of taking breakfast; none, 1 to 2 times/wk, 3 to 5 times/wk, and daily (chi-square for linear trend: 12; P<.001).

The most sensitive criteria for the diagnosis of the metabolic syndrome were (**Tables 1 and 5**) those of de Ferranti et al,[21] with a prevalence of 18% (95% CI: 14%–21%), and the least sensitive were those of IDF,[16] with a prevalence of 2% (95% CI: 1%-3%).

Number Needed to Neglect a child in need of intervention can be computed, comparing the prevalence of waist circumference >75th percentile (673/2149=0.31) with that of metabolic syndrome-IDF (42/2149=0.02) and de Ferranti et al (377/2149=0.18). Absolute risk differences compute to 0.29 and 0.13, and the Numbers Needed to Neglect, 4 and 8 respectively.

Only 6% (95% CI: 4%–8%) of the children with waist circumference >75th percentile and 5% (95% CI: 4%–7%) of those with BMI above 75th percentile were diagnosed as positive for the syndrome, according to the IDF criteria.

DISCUSSION

If cardiometabolic risk is identified with a diagnosis of the metabolic syndrome, a prevalence of 2% (IDF) or even 18% (de Ferranti et al) may not get the decision makers' attention. Individual risk factors, however, present a much sinister picture, which is more likely to help gain common support for the public health agenda.

In view of the known global and national burdens of chronic disease and cardiometabolic risk, focusing at individual risk factors seems to be a more realistic, effective, and practically a useful strategy for primary preventive initiatives, not only for management but also for overcoming the much resilient social inertia.

We have found obesity to be much more prevalent (15% vs 7%) than reported previously among Saudi children.[44] Central adiposity, defined as waist circumference above 75th percentile, was more prevalent (31%) than overweight (14%) and obesity (15%) put together. Fourteen per cent of children with even normal weight had waists above 75th percentile.

Although waist circumference showed the strongest relative correlation with the triglycerides-to-HDL ratio—the most useful markers of insulin resistance next to the plasma insulin concentration[45-49]—it is not part of the routine examination in well baby clinics.

One of the unexpected findings has been the high proportion of underweight children, almost 13%, much higher than reported (6.9%) previously.[50] Our assessment was based on BMI-for-age growth charts from centers for disease control and prevention, United States—reported to be representative for the Saudi population.[51] More than 74% of the underweight children in this study were males. Unlike other cultures where the female child has a higher risk of being undernourished,[52] a higher prevalence of underweight and malnutrition among male children has previously been reported in the Middle East,[50,53] which may be a culture-specific phenomenon and requires further study. This high prevalence of under-nutrition in the youth of such a prosperous nation warrants a careful second look and may raise questions about the effectiveness of primary health care and school health systems.

More than half of these children had HDL values less than 1.3 mmol/L, a cutoff used for the diagnosis of metabolic syndrome.[21] Low HDL-c points to low physical activity, reflected by the fact that less than a quarter (23%) of these children participated in daily sports. This is alarming because childhood is traditionally seen as a time of tireless activity.

Another surprise was the high prevalence of prehypertension (blood pressure above 90th percentile) found in 52% of the children. This apparent overestimation might have resulted because the reference percentiles from the United States National Heart, Lung, and Blood Institute[54,55] were not representative of the population. There is also a distinct possibility of systematic error in the measurement process. As the staff was well trained and the equipment well tested, the only source of such error may be the settings in which measurements were made, which probably would have induced anxiety in the subjects. Planning for surveys involving dynamic physiological responses, especially for children, should include careful control of the environments in which the subjects are examined.

Regardless of the possibility or the degree of overestimation, higher blood pressure in this group did exhibit a consistent and significant relationship with waist circumference, BMI, and triglycerides-to-HDL ratio. This stumble, after all, may prove to be serendipitous in nature.

Because there is a relationship between autonomic activity and lipid metabolism,[56] perhaps it can be suggested that children with earlier signs of increased cardiometabolic risk are high autonomic responders, liable to react to novel situations with higher adrenaline levels than a child without such risk. This hypothesis, if credible, needs more exploration and further studies.

The reversal of cardiometabolic risk profile starting the 12th year of age may be related to hormonal changes during these years. The observation needs confirmation by further studies.

In addition to the lack of exercise, another basic aspect of lifestyles—diet—also appears to be in want of attention. More than 40% of these children did not take daily breakfast. This may lead to higher consumption of fast food and beverages during school hours, as those who did take daily breakfast, had a significantly lower prevalence of obesity. Activity and diet are aspects of lifestyle that are influenced by a continuum of environments from home to school to society in general—making cultural, societal, and educational changes equally important and desirable.

More than 80% of children who would benefit with lifestyle and dietary interventions would be missed if the diagnosis of higher cardiometabolic risk were based on a specific compound measure like the metabolic syndrome, rather than simple clinical morphometric indicators.

A high prevalence of diabetes, coronary heart disease, and their risk factors in most cultures is a given fact by now; Saudi Arabia is no exception.[33-37] The importance of preventive efforts aimed at reducing the prevalence of these risk factors cannot be overstressed. Such interventions need to be directed at population groups offering the maximum leverage for change. Pediatrics age group offers such leverage, and primary health care and education are the interfaces that must be strengthened for any possibility of success of interventional measures.

Expenses beyond the simplest routine ones can translate into huge budget differences for population-based programs running over a long term. Any detraction from the simplest and the least costly screening to detect the need for preventive interventions can prove to be a certain formula for ensuring the failure of such programs.

There is a need for specially tailored and intensified health care and educational initiatives in primary care and schools with the aim of not only creating insights and awareness, but also for inculcating healthier habits early on, aiming at societal and cultural changes in the long run.

Primary health care and primary schools may be the real last bastions of the communities' struggle against the rising tide of cardiometabolic disorders, and mechanisms need to be generated for the two to work in collaboration in this respect. In the end, only the good old family doctor and the school teacher, with much-needed collaboration, may come to our rescue.

In conclusion, primary care workforce should assess waist circumference and BMI-for-age as indicators of increased cardiometabolic risk. Education and health care sectors need to develop collaborative school-based programs for early risk detection and lifestyle education.

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