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Clustered cardiovascular disease risk among children aged 8–13 years from lower socioeconomic schools in Gqeberha, South Africa

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ABSTRACT

Objectives To determine the prevalence of individual cardiovascular disease (CVD) risk factors and clustered CVD risk among children attending schools in periurban areas of Gqeberha and to investigate the independent association between clustered CVD risk, moderate to vigorous physical activity (MVPA) and cardiorespiratory fitness (CRF).

Methods Baseline data were collected in a cross-sectional analysis of 975 children aged 8–13 years. We measured the height, weight, waist circumference, blood pressure, fasting glucose, full lipid panel, 20 m shuttle run performance and accelerometry. The prevalence of individual risk factors was determined, and a clustered risk score (CRS) was constructed using principal component analysis. Children with an elevated CRS of 1 SD above the average CRS were considered 'at-risk'.

Results We found 424 children (43.3%) having at least one elevated CVD risk factor: 27.7% elevated triglycerides, 20.7% depressed high-density lipoprotein cholesterol and 15.9% elevated total cholesterol. An elevated clustered risk was identified in 17% (n=104) of the sample; girls exhibited a significantly higher CRS >1 SD than boys (p=0.036). The estimated odds of an elevated clustered risk are doubled every 2 mL/kg/min decrease in VO$_2$max (95% CI 1.66 to 3.12) or every 49 min reduction in MVPA (95% CI 27 to 224).

Conclusion A relatively high prevalence of elevated individual and clustered CVD risk was identified. Our results have also confirmed the independent inverse association of the clustered CVD risk with physical activity and CRF. These indicate that increased levels of CRF or MVPA may aid in the prevention and reduction of elevated clustered CVD risk.

INTRODUCTION

Globally, the leading causes of death are cardiovascular diseases (CVD).[1] Closely related CVD risk factors (central obesity, hypertension, hyperglycaemia and dyslipidaemia) are known to cluster and cause physiological changes, a phenomenon referred to as metabolic syndrome (MetS).[2] MetS is a condition where elevated CVD risk factors increase the risk for CVD and type 2 diabetes.[3] MetS was usually diagnosed among adults: however, the prevalence of MetS has become evident among children and adolescents.[3 4] Attempts have been made to establish the diagnostic criteria for MetS among children and adolescents by organisations such as the International Diabetes Federation (IDF) and the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III), and the WHO.[2] However, there is still no clear consensus for MetS in the paediatric population as the definitions and their

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Evidence shows that children with clustered risk factors are at an increased risk of developing cardiovascular disease and type 2 diabetes in adulthood, but little is known about the prevalence of clustered cardiovascular disease risk in underserved communities and schools such as those in the Gqeberha, Eastern Cape region of South Africa.

WHAT THIS STUDY ADDS

⇒ This is the first known study to present both individual and clustered risk factor prevalence for cardiovascular disease among children aged 8–13 years attending non-fee-paying government schools.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE AND/OR POLICY

⇒ This study contributes to the growing body of knowledge highlighting the importance of moderate to vigorous physical activity and cardiorespiratory fitness and emphasises their separate pathways in reducing risk for clustered cardiovascular disease risk in children.

⇒ These findings underscore the importance of an active lifestyle to counteract early-life cardiovascular risk.

cut-offs vary. An alternative to applying a MetS definition is calculating a clustered risk score (CRS) based on CVD risk factors. There is evidence that children with clustered risk factors are at an increased risk of developing CVD and type 2 diabetes in adulthood.[5] Researchers like Andersen *et al*[6] and Ekelund *et al*[7] constructed a CRS by summing the z-scores of the risk factors. Others like Peterson *et al*[8] used principal component analysis (PCA) to calculate the CRS: the PCA calculates the factor coordinates (multipliers) for each risk factor instead of assuming all risk factors have an equal contribution to the CRS.

Only two South African studies have investigated the prevalence of CVD risk among children and adolescents. The first was conducted by Matsha *et al*[9] who compared the NCEP ATP III and IDF definitions in the Western Cape. The second was conducted by Sekokotla *et al*[10] in Mthatha, Eastern Cape, using an adjusted definition of the NCEP ATP III criteria. Two recent studies conducted in the Eastern Cape tested the independent association of cardiorespiratory fitness (CRF) and physical activity (PA) with clustered CVD risk. Still, they did not investigate the clustered CVD prevalence.[11 12] However, CVDs are one of the predominant categories of non-communicable diseases (NCDs). NCDs are major drivers of healthcare costs in countries like South Africa (SA) which have a high NCD profile.[13] Moreover, in the periurban zones of SA, harsh socioenvironmental conditions perpetuate the NCD cycle.

Given the inconsistency in standardised MetS criteria, and the limited research on South African children, the aim of the current study was twofold: first, to determine the prevalence of both individual and clustered CVD risk factors among children attending primary schools in under-resourced periurban settings; second, to examine the independent association of a clustered CVD risk with PA and CRF, respectively.

METHODOLOGY
Study design
A cross-sectional analysis of the baseline data derived from the KaziBantu study was conducted. The KaziBantu study aimed to assess the effect of a school-based health intervention on risk factors for NCDs, health behaviours and psychosocial health in primary school children in disadvantaged communities in Gqeberha, SA.

All required procedures were followed, including Good Clinical Practice guidelines and the ethical principles defined in the Declaration of Helsinki.[14]

Patient and public involvement
School principals were informed about the study at a meeting 3 months before data collection (October 2018), and parents/guardians were informed about the project through study information newsletters. The research question and methods were developed and based on literature.[11 12] Participants and the public were not involved in the study design, recruitment and implementation of

the study nor the choice of outcome measures. The study outcome and recommendations will be communicated to the Eastern Cape Department of Education so children, especially those attending schools in under-resourced communities, can benefit from these recommendations.

Participants
In SA, schools are divided into five quintiles (Q), with the poorest schools allocated to Q1 (Q1–Q3 are non-fee-paying schools and are considered 'disadvantaged'). About 64 principals from Q3 primary schools expressed interest in the study, of which 40 schools invited the research team to share the study information with their staff. Eventually, eight schools matched the inclusion to participate.[15] Children were selected from grades 4–6 (8–13 years old). One class was selected per grade based on the highest consent return rate, totalling three classes per school. Children were included if they met the following criteria: (1) oral assent, (2) written informed consent from parent/guardian, (3) not involved in other clinical trials during the study period, (4) and not suffering from medical conditions that prevented participation in the study, as determined by medical personnel. Recruitment closed in January 2019. A total of n=1020 children agreed to participate. Due to incomplete data sets, the data of 975 children (474 girls) were available for further analysis.

Socioeconomic status
Children completed a questionnaire on asset ownership and housing characteristics to determine their socioeconomic status (SES). Asset ownership was based on the availability of items. In contrast, housing characteristics were based on infrastructure and utilities, such as the type of building, the number of people per number of rooms, toilet type, access to running water, access to electricity and the fuel used for cooking. The data were used to generate an SES index created using PCA. Evidence of the reliability and validity of asset ownership and housing characteristics questionnaires has been published in a prior study.[16]

Assessment of cardiovascular risk factors
A detailed description of the procedures can be found in the *KaziBantu* study protocol.[15] Standardised guidelines were used to obtain anthropometric measurements: weight, height and waist circumference.[17] To determine the body composition, the authors calculated the body mass index (BMI) and measured the body fat percentage (BF%) via bioelectrical impedance analysis (Tanita MC-580; Tanita, Tokyo, Japan). Blood pressure (BP) was assessed with a validated oscillometric digital BP monitor (Omron M6 AC; Hoofddorp, Netherlands). Capillary blood samples were assessed using the Alere Afinion AS100 analyser (Abbott Laboratories, Illinois, USA). Via fingerprick, two drops of blood were taken to assess total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol

Table 1 Critical levels for eight risk factors

Risk factor	Critical level	Reference
BMI	≥90th percentile of the sample	Cole et al[38]
Waist circumference	≥90th percentile of the sample	Zimmet et al[2]
BP	≥90th percentile of the sample	Flynn et al[39]
HbA1c	≥39 mmol/mol	American Diabetes Association[40]
HDL-C	<1.03 mmol/L	McNeal et al[41]
LDL-C	≥2.8 mmol/L	McNeal et al[41]
Total cholesterol	≥4.4 mmol/L	McNeal et al[41]
Triglycerides	<10 years, ≥0.85 mmol/L ≥10 years, >1.02 mmol/L	McNeal et al[41]

BMI, body mass index; BP, blood pressure; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

(LDL-C), triglycerides and glycated haemoglobin (HbA1c). Evidence of this fingerprick method's clinical utility and accuracy has been described previously.[18 19]

Cardiovascular risk factor cut-offs
Cut-offs were defined for each risk factor to determine the CVD risk. See table 1.

Physical activity
PA was measured using a light triaxial accelerometer device (ActiGraph wGT3X-BT; ActiGraph, Pensacola, USA), which has proven to accurately measure daily activities for children.[20] Children wore the device around the hip for seven consecutive days except during activities involving water contact. A 30 Hz sampling rate was used, and data were stored as GT3X raw files. Analyses were performed with the ActiLife software (V.6.13.2; ActiGraph) using 10 s epoch lengths. Non-wear time was calculated with the algorithm developed by Troiano and colleagues.[21] The data were considered valid if the child wore the device for at least 8 hours out of 24 hours on ≥4 weekdays and ≥1 weekend day.[22] Cut points for children defined by Evenson et al[23] were used to calculate an overall index for moderate to vigorous physical activity (MVPA).

Estimated VO$_2$max
Children's CRF was assessed with the 20 m shuttle run test adhering to the protocol by Léger et al.[24] The number of fully completed laps was recorded after the learner failed to reach the 20 m turn-line on two consecutive intervals. The number of laps was used to calculate the estimated VO$_2$max (adjusted for age and sex).

Statistical analysis
The collected data were double entered and validated in EpiData V.3.1 (EpiData Association; Odense, Denmark). All statistical analyses were obtained using Statistica V.13 (TIBCO Software, Palo Alto, USA) and Microsoft Office Excel 2013 (Microsoft, Redmond, USA). Descriptive data are displayed as the sample size (n), mean (M) and SD for all measured variables. The authors used analysis of variance to determine whether the observed differences between the means of the variables for both sexes were statistically significant. To validate inferential statistics, the eight risk factors listed in table 1 were first transformed to normality using the Box-Cox transformation and were subsequently z-standardised.

First, the individual CVD risk factors were selected, and then binary variables were created using cut-offs given in table 1. Children were assigned a *one* (1) when they exceeded the given cut-off or a *zero* (0) otherwise.

Second, a CRS was calculated as a linear combination of the eight CVD risk factors, where the individual weights associated with each risk factor were obtained using a PCA. The factor coordinates of the first extracted PCA were used as multipliers for the eight risk factors to calculate the CRS. The CRS was also z-transformed to facilitate the interpretation in SD units. We followed previously published recommendations[6] to determine the degree of clustering. Participants who exhibited an elevated CRS of 1 SD above the average CRS (CRS >1 SD) were defined as at risk and were assigned a *one* (1) or *zero* (0) otherwise. Pearson's χ^2 test determined whether differences observed for an elevated CRS between boys and girls were statistically significant.

Finally, to determine the independent effects of MVPA and VO$_2$max on the risk of an elevated CRS, a logistic regression model was used, where the dependent binary variable was CRS >1 SD. The model included age, SES and sex as covariates. To study the effect of VO$_2$max on CRS >1 SD, the model was controlled for age, SES, sex and MVPA. The logistic model did not detect a significant difference between the probabilities of a CRS >1 SD of girls and boys (p=0.144). Thus, in the subsequent logistic regression, the sex of the children was ignored. The estimated probabilities of CRS >1 SD at various levels of VO$_2$max were calculated. To study the effect of MVPA on CRS >1 SD, the model controlled for the confounding effects of age, SES and VO$_2$max. Using the estimated coefficients produced by the logistic regression, the probabilities of CRS >1 SD were calculated for various levels of MVPA.

RESULTS

A total of 424 (43.3%) children presented with at least one risk factor. Table 2 shows the descriptive statistics for the total group and separately for boys and girls.

According to table 2, girls presented with higher mean values for all CVD risk factors except HbA1c and HDL-C. Statistically significant sex differences were noted for weight (p=0.0008), BMI (p=0.0001), BF% (p<0.0001), total cholesterol (p=0.0287) and triglycerides (p<0.0001). The effect size was of small practical significance for weight (d=0.22), BMI (d=0.25) and triglycerides (d=0.36), while BF% (d=0.85) showed large practical significance. Boys had significantly higher CRF (p<0.0001; d=0.54) and MVPA values (p<0.0001; d=0.93) than girls. These differences were both statistically and practically significant.

Table 3 shows the percentage of children at risk for each CVD risk factor and the corresponding 95% CI for the total group and girls and boys separately. Almost 30% of the children had elevated triglycerides. More girls had elevated triglycerides than boys (p<0.001), but this difference was of small practical significance (ϕ=0.171). The three individual risk factors with the highest number of children at risk were triglycerides, total cholesterol and depressed HDL-C from the lipid test battery. The glucose test (HbA1c) was the fourth most prevalent. BMI was the only CVD risk factor to show a sex difference that was statistically (p=0.008) and practically (ϕ=0.089) significant.

Seventeen per cent (n=104; 62 girls) of the sample had an elevated CRS. Girls presented with a significantly higher risk of an elevated CRS than boys (χ^2=4.39, p=0.036). The estimated odds for girls to present with an elevated CRS is 1.6 times higher than for boys (95% CI 1.02 to 2.42).

Figure 1 gives the average trend for the probability of an elevated CRS as a function of VO_2max at the medians of age, SES and MVPA. The estimated probability of CRS >1 SD for 10-year-old children at median SES, MVPA and VO_2max values was 8.9%. At any given value for age, SES and MVPA, the estimated odds of an elevated CRS are halved for every increase of 2.17 mL/kg/min in VO_2max (95% CI 1.66 to 3.12).

Figure 2 shows the estimated probability of an elevated CRS as a function of MVPA at the medians of age, SES and VO_2max. The probability of an elevated CRS above the average CRS for a 10-year-old child, at 60 min of MVPA per day and median values for the covariates, is 10.1%. The estimated odds of an elevated CRS above the average CRS are halved for every increase of 49 min spent in MVPA (95% CI 27 to 224).

DISCUSSION

The purpose of the current paper was to determine the prevalence of individual risk factors and clustered CVD risk among children in selected periurban zones of Gqeberha, SA, and investigate the independent association of clustered CVD risk with MVPA and CRF.

Individual and clustered CVD risk

Results showed that 43.3% of children presented with at least one elevated CVD risk factor. The three most common CVD risk factors were elevated triglycerides (27.7%), depressed HDL-C (20.7%) and elevated total cholesterol (15.9%). However, these results are relative to pubertal development[25 26] and should be interpreted with caution as 9.92% of girls in the current sample had self-reported age at menarche. Our findings correlate with a recently published study which also found depressed HDL-C to be a common risk factor in a sample of 142 142 children and adolescents.[27] A general and yet consistent finding is for total cholesterol to decrease during sexual maturation while patterns of change vary across studies for triglycerides and lipoprotein-cholesterol fractions.[25]

Age-related developmental differences impact MetS diagnostic criteria among children and adolescents. In a cohort with a similar age range to the present (8–13 years old), Cruz et al[28] used a MetS definition (NCEP ATP III) and reported a MetS prevalence of 30% among Hispanic children who were overweight and at high risk of type 2 diabetes. Literature[2 3] does, however, urge researchers not to diagnose MetS in children younger than 10 years old, hence why we constructed a CRS instead of applying a specific MetS definition to the current sample in which more than 500 children were younger than 10 years old. Using the CRS >1 SD, a clustered CVD risk prevalence of 17% was found in the present sample. Literature reflects varying MetS rates. Tailor et al[29] provided a worldwide update on the prevalence of MetS among children and adolescents, ranging from 1.2% to 22.6%; however, none of the included studies were from Africa. A systematic review and meta-analysis[27] of 76 studies reported a pooled prevalence of MetS in Africa (6.03%, 95% CI 0.24% to 11.28% for the IDF definition; and 6.71%, 95% CI 5.51% to 7.91% for the ATP III definition) which only included two studies from SA,[9 10] the other study was from Ethiopia (a prevalence of 12.4% was reported among an adolescent sample).[30] The two South African studies included children older than 10 years old. Therefore, applying a MetS definition was acceptable. From the rural parts of Mthatha in the Eastern Cape of SA, Sekokotla et al[10] identified a MetS prevalence of 5.9% using the NCEP ATP III definition among adolescents aged 13–18 years. Meanwhile, in the metropolitan city of Cape Town in the Western Cape, Matsha et al[9] did a comparison study and reported a prevalence of 6.5% when applying the NCEP ATP III definition and only 1.9% using the IDF definition among participants aged 10–16 years.

The function of CRF and PA for CVD risk

The present study corroborates the findings of the previous studies[6 11 12 31] where the protective function of both CRF and PA reduced the probability of elevated clustered CVD risk factors in children. Our results showed a halving of an elevated clustered CVD risk for every 2.17 mL/kg/min increase in VO_2max (95% CI 1.66 to 3.12) or every 49 min increase in MVPA (95% CI 27 to 224).

Table 2 Demographics of children as assessed in underprivileged primary schools in Gqeberha, SA, in February/March 2019

	Total			Girls			Boys			P value	Cohen's d
	n	M (SD)	95% CI	n	M (SD)	95% CI	n	M (SD)	95% CI		
Age	922	10.41 (1.19)	10.34 to 10.49	451	10.23 (1.13)	10.12 to 10.33	471	10.59 (1.22)	10.48 to 10.70	<0.0001	−0.31
SES	848	74.73 (14.17)	73.77 to 75.68	429	74.16 (13.82)	72.85 to 75.47	419	75.31 (14.52)	73.91 to 76.70	0.2370	−0.08
Height (cm)	932	139.88 (8.86)	139.31 to 140.5	455	140.22 (8.96)	139.39 to 141.04	477	139.56 (8.76)	138.77 to 140.35	0.2568	0.07
Weight (kg)	922	35.61 (10.13)	34.95 to 36.26	451	36.75 (11.00)	35.73 to 37.77	471	34.51 (9.09)	33.69 to 35.33	0.0008	0.22
BMI (kg/m²)	922	17.98 (3.68)	17.74 to 18.21	451	18.45 (4.04)	18.08 to 18.82	471	17.52 (3.24)	17.23 to 17.82	0.0001	0.25
Body fat (%)	922	23.64 (6.88)	23.20 to 24.09	451	26.41 (6.28)	25.83 to 26.99	471	21.00 (6.37)	20.42 to 21.57	<0.0001	0.85
Waist circumference (cm)	917	58.43 (7.89)	57.92 to 58.94	452	58.81 (8.25)	58.04 to 59.57	465	58.07 (7.52)	57.39 to 58.76	0.1584	0.09
Systolic BP (mm Hg)	944	108.92 (13.43)	108.06 to 109.78	466	109.29 (13.75)	108.04 to 110.54	478	108.57 (13.12)	107.39 to 109.74	0.4101	0.05
Diastolic BP (mm Hg)	944	67.17 (10.93)	66.47 to 67.87	466	67.84 (10.83)	66.85 to 68.83	478	66.51 (11.01)	65.52 to 67.50	0.0619	0.12
HbA1c (mmol/mol)	766	35.6 (2.60)	35.47 to 35.83	383	35.61 (2.46)	35.36 to 35.86	382	35.68 (2.68)	35.41 to 35.95	0.6870	−0.03
Total cholesterol (mmol/L)	757	3.74 (0.66)	3.69 to 3.78	379	3.79 (0.63)	3.72 to 3.85	378	3.68 (0.69)	3.61 to 3.75	0.0287	0.16
LDL-C (mmol/L)	748	2.03 (0.54)	2.00 to 2.07	375	2.07 (0.53)	2.01 to 2.12	373	2.00 (0.56)	1.94 to 2.06	0.1004	0.12
HDL-C (mmol/L)	757	1.29 (0.31)	1.27 to 1.32	379	1.27 (0.29)	1.24 to 1.30	378	1.31 (0.32)	1.28 to 1.35	0.0725	−0.13
Triglycerides (mmol/L)	757	0.92 (0.55)	0.88 to 0.96	379	1.02 (0.66)	0.95 to 1.08	378	0.82 (0.38)	0.78 to 0.86	<0.0001	0.36
CRF/VO₂max (mL/kg/min)	918	46.98 (5.77)	46.62 to 47.38	455	45.48 (5.05)	45.01 to 45.94	462	48.46 (6.04)	47.91 to 49.01	<0.0001	−0.54
MVPA (min/day)	920	72.99 (28.25)	71.16 to 74.82	456	61.01 (21.96)	58.99 to 63.03	464	84.76 (28.80)	82.14 to 87.39	<0.0001	−0.93

Statistical significance at p<0.05. The variation in the n values per variable results from missing data. Effect sizes (Cohen's d) are interpreted as follows: d<0.2, no difference; d=0.20–0.49, small difference; d=0.50–0.79, medium difference; d≥0.80, large difference.
BMI, body mass index; BP, blood pressure; CRF, cardiorespiratory fitness; HDL–C, high-density lipoprotein cholesterol; LDL–C, low-density lipoprotein cholesterol; MVPA, moderate to vigorous physical activity; SA, South Africa; SES, socioeconomic status.

Table 3 Percentage of children at risk for each risk factor in underprivileged primary schools in Gqeberha, SA, in February/March 2019

	Total group		Girls		Boys			
Risk factor	n (%)	95% CI	n (%)	95% CI	n (%)	95% CI	P value	Phi
BMI (kg/m^2)	895 (11.5)	9.4 to 13.6	445 (14.4)	11.1 to 17.6	450 (8.7)	6.1 to 11.3	0.008	0.089
Waist circumference (cm)	879 (10.4)	8.3 to 12.4	442 (10.4)	7.6 to 13.3	437 (7.4)	7.4 to 13.1	0.118	0.053
Systolic BP (mm Hg)	898 (12.5)	10.3 to 14.6	447 (11.9)	8.9 to 14.9	451 (13.1)	10.0 to 16.2	0.587	−0.018
Diastolic BP (mm Hg)	898 (11.4)	9.3 to 13.4	447 (10.7)	7.9 to 13.6	451 (12)	9.0 to 15.0	0.539	−0.020
HbA1c (mmol/mol)	766 (13.7)	11.3 to 16.1	383 (12.5)	9.2 to 15.8	382 (14.7)	11.1 to 18.2	0.375	−0.032
Total cholesterol (mmol/L)	757 (15.9)	13.3 to 18.5	379 (16.4)	12.6 to 20.1	378 (15.3)	11.7 to 19.0	0.679	0.015
LDL-C (mmol/L)	748 (7.2)	5.4 to 9.1	375 (7.2)	4.6 to 9.8	373 (7.2)	4.6 to 9.9	1.000	0.00
HDL-C (mmol/L)	757 (20.7)	17.9 to 23.6	379 (24.0)	19.7 to 28.3	378 (17.5)	13.6 to 21.3	0.027	0.080
Triglycerides (mmol/L)	757 (27.7)	24.6 to 30.9	379 (35.4)	30.5 to 40.2	378 (20.1)	16.1 to 24.1	<0.001	0.171

Statistical significance at p<0.05. The variation in the n values per variable results from missing data. The effect size was determined by using phi (ϕ). A value of $\phi=0.1$ represents a small effect, 0.3 a medium effect and 0.5 a large effect.
BMI, body mass index; BP, blood pressure; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SA, South Africa.

In SA, it is estimated that 35.8%–51.7% of children,[32 33] and about 36% of adolescents,[34] meet the international recommendation of at least 60 min of daily MVPA. A large percentage of the current sample (72.99%) achieved this recommendation (table 2). Even though girls managed to reach the ≥60 min daily recommendation, the difference between the sexes was still of statistical (p<0.001) and practical significance (d=−0.93). Consequently, girls should be encouraged to be more active as they exhibited a significantly higher probability of CRS >1 SD than boys (p=0.036).

The gender difference for CRF was also of statistical significance (p<0.001) with a medium effect size (d=−0.54). Girls achieved an average value of 45.48 mL/kg/min, and boys an average of 48.46 mL/kg/min (table 2). According to Ruiz et al,[35] the 95% CI region of CRF associated with low CVD risk for children (8–17 years old) ranges from 41.8 to 47.7 mL/kg/min for boys and 34.6 to 39.5 mL/kg/min for girls. To avoid CVD risk, the CRF cut points are 41.8 and 34.6 mL/kg/min for boys and girls, respectively.[35] Based on these cut points, the fitness levels of the current sample did not raise a red flag in respect of CVD.

Limitations

Due to the cross-sectional design of this study, we are unable to report on causal inference. Furthermore, our findings cannot be generalised to all South African children, as only children from one out of the nine provinces were included in this investigation. In addition, our restricted inclusion of sexual maturity may limit our understanding of the influence of maturation on CVD
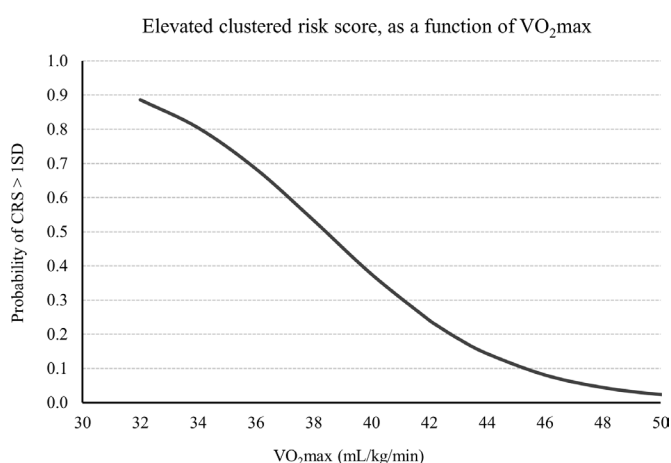

Figure 1 Estimated probability of clustered risk score (CRS) >1 SD, as a function of VO$_2$max, at the median values for age, socioeconomic status (SES) and moderate to vigorous physical activity (MVPA).
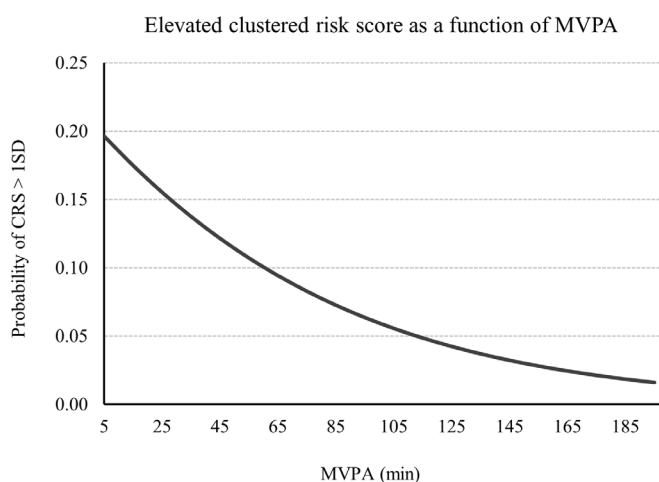

Figure 2 Estimated probability of clustered risk score (CRS) >1 SD, as a function of moderate to vigorous physical activity (MVPA), at the median values for age, socioeconomic status (SES) and VO$_2$max.

variables during puberty. Finally, estimating children's VO$_2$max via the 20 m shuttle run test is not without criticism.[36] However, this test is currently the most widely used field-based measurement of CRF in children.[37]

CONCLUSION

A relatively high prevalence of elevated individual and clustered CVD risk was identified in this cohort of children from Q3 schools living in selected communities of Gqeberha, SA. Our findings confirm the independent association of the clustered CVD risk with PA and CRF, respectively. Our findings also support previous work among South African primary school children showing that elevated clustered CVD risk decreases with an increase in CRF or MVPA.[11 12]

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