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Physical Activity and Metabolic Risk Factors among Jamaican Adolescents

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Abstract

The study examined relationships between physical activity (PA) and Metabolic Syndrome (METS) in Jamaican adolescents. A descriptive, cross-sectional survey examined 276 students from 10 Jamaican high schools. The National Cholesterol Education Program (NCEP) Adult Treatment Panel III and the International Diabetes Federation (IDF) criteria determined the metabolic risks. The Physical Activity Questionnaire for Children measured PA levels.

Mean age was 15.6 (± 1.2). Percentage of subjects classified with METS varied by criterion used; IDF (6.9%) and NCEP (12.4%). While 56% of the subjects classified with METS were physically inactive, logistic regression showed no relationships between PA and individual METS risk factors overall ($p>0.05$). Females were 15 times less physically active and had significantly ($p<0.05$) higher waist circumference (WC) than males, whereas, males had significantly ($p<0.05$) higher fasting blood glucose levels. Although urban adolescents had higher PA than rural adolescents, they had significantly ($p<0.05$) higher WC; one of the determinants of METS by IDF's standard. Similarly, under the IDF's classification, Blacks had significantly higher numbers of METS risk factors ($p<0.05$) compared to non-Blacks.

Jamaican adolescents are at risk for METS irrespective of levels of PA. Living in urban areas, being female, and being Black increased the risk for METS. NCEP guidelines classified more subjects with METS compared with IDF's. Intervention measures are needed to reduce METS risk factors among this population.

Keywords: Physical activity; Type 2 diabetes; Cardiovascular diseases; Metabolic syndrome

Introduction

Low Physical Activity (PA) and associated risks for chronic diseases are increasing in the adolescent population [1,2]. Greater PA has been linked to the protection from heart disease, certain cancers, prevention or control of type 2 diabetes (T2D), and reducing the risks for metabolic syndrome (METS) [3,4].

METS is a cluster of three or more risk factors for cardiovascular diseases (CVDs) and includes central adiposity, hypertension, high fasting blood glucose, hypertriglyceridemia, and decreased high density lipoprotein cholesterol (HDL-C). Increased prevalence of the individual components and/or clustering of the components of METS are associated with CVD and T2D among American adolescents [1,2,5]. To date, much of the research on METS in adolescents is related to obesity and insulin resistance [6-8]. PA and METS have been studied mostly in the adult population [9,10].

Despite evidence of the health benefits of PA [3,4], there is little research on PA and METS in adolescents. Pan and Pratt [5] found a 3.5% prevalence of METS among US adolescents with more males than females presenting with METS. Higher prevalence of METS was associated with lower PA in that study. The same dynamics were expected among Jamaican adolescents, many of whom have been exposed to Western lifestyles (low physical activity and high intakes of high-fat foods) by electronic media; television viewing and the widespread availability of the internet [11,12]. Jamaican adults exhibited evidence of metabolic risk factors in earlier studies [13-15]. Ferguson et al. [15] found an overall prevalence of 1.2% for METS among Jamaican adolescents' ages 18-20 years but did not study PA. A higher percentage of females than males presented with METS in that study.

Although it is recognized that increased PA is beneficial in reducing the number of risk factors for METS [5,16], this relationship, among the Jamaican adolescent has not been examined. Researchers have found that Jamaican adolescents and adults are not sufficiently physically active [14,15,17], but the prevalence of METS and its relationship to PA were not examined in those studies.

Research on PA shows significant improvements for reducing chronic diseases related to METS [16]. The Center for Disease Control and Prevention (CDC) estimated that increased numbers of physically active persons could help to reduce the direct medical costs in the US by as much as $70 billion yearly [18]. Similarly, a reduction in the health care costs attributable to METS and low PA of Jamaican adolescents may be achieved. The study reported here was part of a larger study on Jamaican adolescents' risk for METS (name withheld for blind review). This study examined the relationship between PA and metabolic risk factors among Jamaican adolescents. We hypothesized that low PA would be associated with higher risk for METS in this population.

Materials and Methods

Participants

A total of 300 Jamaican adolescents ages 14 -19 years from grades 9-12 participated in the study. Subjects were selected by a stratified

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process from ten high schools in Jamaica. Schools were clustered by parishes, and five of the 14 parishes were randomly selected. Schools within each parish were classified as traditional (schools which offer more academic subjects and typically cater to middle and upper class families) and non-traditional (schools which offer a vocational orientation) to obtain a sample representing multiple socioeconomic status (SES) levels. Two schools per parish were randomly selected from each school type. Subjects were further stratified by grade levels and gender, and 30 subjects per school were randomly selected. A sample size of 300 was sufficient to yield 99% power to detect an R2 of 0.10 using an F-test with a significance level of 0.05 [19]. Two hundred seventy-six students, 112 males and 164 females aged 14-19 years participated in the study (92% participation rate). Data were collected over three weeks in October 2007, following approval by Florida International University, Miami, Florida, the Division of Standards and Regulations Ministry of Health and Environmental Control, and the Ministry of Education and Youth, Kingston, Jamaica.

Procedure

A contact person (CP) was recruited within each school. The CPs helped to organize students on data-collection days. Parental written consent and students' assent were obtained. Subjects were screened to determine whether they were on medications known to alter blood pressure, glucose, or lipid metabolism, as these were exclusion criteria. Students reported for the assessment at 7:30 a.m. in each school, where their fasting status was ascertained on arrival. Weights, heights, waist circumference (WC), and blood pressure (BP) were taken, after which blood was tested by finger prick for fasting blood glucose (FBG), total cholesterol (TC) and glycated hemoglobin (A1c). After completion of all anthropometric measures and blood tests, students were served a continental breakfast to offset hypoglycemic episodes. Students completed the demographic and PA questionnaires and returned them to the researcher. Assessments were completed within three hours per school, and subjects were given small stipends for participation.

Description of instruments

The self-administered Physical Activity Questionnaire for Children (PAQ-C) assessed general PA levels during the school year. Acceptable levels of test-retest reliability for both males (r=0.75) and females (r=0.82) ages 9-15 years have been established for the PAQ-C [20]. The instrument consisted of 9 items that assessed activity levels at different times of the day including in-school and out-of-school activities. Items were scored on a scale of 1-5, where 1=inactive (non-participation in that particular activity); 2=low activity level (activity is performed 1-2 times), 3=moderately active (activity is performed 3-4 times);

4=active (activity is performed 5-6 times); 5=very active (activity is performed > 7 times) in the past week. The 9 items were summed, then averaged to determine the weekly activity level of adolescents. For the current study, PA levels were coded as 0=low (activity performed 0-2 times/week) and 1=physically active (activity performed >2 times/week).

Measuring the risk factors for metabolic syndrome

Metabolic syndrome is diagnosed if three or more of the following selected risk factors are present: central obesity, high blood pressure, high triglycerides, low HDL-C, and fasting hyperglycemia [21,22]. In the current study, fasting blood glucose (FBG), total cholesterol (TC), glycated hemoglobin (A1c), blood pressure (BP), and waist circumference (WC) were used to determine the presence of METS. Both the National Cholesterol Education Program (NCEP) [21] and the International Diabetes Federation (IDF) [23] standards were used to classify subjects at risk for METS. The IDF's criteria for determining the presence of METS requires a mandatory inclusion of WC and any other two risk factors.

All blood measures were taken using capillary whole blood. FBG, measured by the Accu Chek Advantage Blood Glucose Monitor (Roche Diagnostics of New Zealand), was classified using the American Dietetic Association (ADA) criteria [24], where normal fasting glucose ≤ 100 mg/dL, impaired fasting glucose=100 mg/dL and <126 mg/dl, and glucose levels ≥ 126 mg/dL indicated diabetes. Total cholesterol, tested by the Accutrend GCT Cholesterol Monitor (Roche, Diagnostics, Mannheim, Germany), was classified using the current NCEP guidelines for children [21]. Total cholesterol was classified as normal=< 170 mg/dL, borderline=170-200 mg/dL, and abnormal ≥ 200 mg/dL and was coded as 1=risk (TC>170 mg/dL) and 0=no risk (TC<170 mg/dL) for statistical analyses. A1c was measured using the Nycocard manufactured by Axis-Shield [25]. The results were reported as one standardized A1c value. The IDF reference of ≤ 6.5% was used as the cut-off point for normal levels of A1c.

Blood pressure was measured using a sphygmomanometer after students rested for five minutes. An average of two readings was used to classify students as normal if the mean was below the 90th percentile, pre-hypertensive if they plotted within the 90-95th percentiles, and hypertensive if their BP exceeded the 95th percentile for height, age and sex [26]. Adult values of 140/90 mmHg (similar to the 95th percentile) were used to classify the 17-19 year olds as hypertensive [26].

Waist circumference was taken using standard procedures [27] and was classified as normal (WC <94 cm and <80 cm), or at risk for T2D and CVDs (WC ≥ 94 cm and ≥ 80 cm) for adult males and females, respectively [27].

Statistics

Descriptive statistics such as means, standard deviations, frequencies and percentages for demographic characteristics of the population were determined. Risk factors of METS were coded as 0=no risk and 1=risk, based on previously described criteria. Logistic regression of PA on the risk factors of metabolic syndrome, and the demographic variables were performed. Cross tabulations of different groupings of METS risk factors and the demographic variables were performed. Correlations and Chi Square analyses were performed between PA and each of the individual risk factor for METS to determine the relationship among the frequency of PA and the prevalence of METS, and the proportion of subjects at risk for low PA and METS. Statistical significance was set at 0.05. Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp.

Results

A higher percentage of females compared with males participated in the study (Table 1). Mean age was 15.6 (± 1.2) years. The mean PA score was 2.2 (± 0.6) (Table 1) indicating that subjects participated in physical activities on an average of 1-2 times per week. Figure 1 shows the numbers of subjects classified as at risk for low PA and METS. Of the five risk factors, WC classified the most (n=79) subjects at risk for METS (Table 1).

Under the NCEP-ATP III standards, subjects were classified with METS if they had ≥3 of the following risk factors; high WC, FBG, A1c, BP and TC. Thirty-four (12.4%) of the subjects were classified with METS by this standard. The mean METS score was 3.39 (± 2.24).

Variables	n (%)	Mean (SD)
Gender		NA
Male	112 (40.6)	
Female	164 (59.4)	
Ethnicity		NA
Blacks	215 (77.9)	
Non-Blacks	61 (22.1)	
Place of Residence		NA
Rural	140 (50.7)	
Urban	136 (49.3)	
Household Income		NA
Low (<J$30,000/mth)	204(73.9)	
High	71 (25.7)	
Age (years)		15.6 (1.2)
14-16	214 (77.5)	15.1 (.8)
17-19	62 (22.5)	17.3 (0.5)
Waist Circumference		
No Risk (<94cm M, <80 cm F)	197 (71.4)	79.06 (4.2)
Risk (≥ 94 cm M, ≥ 80 cm F)	79 (29.6)	
Fasting Blood Glucose		91.21 (10.53)
Normal (≤ 100 mg/dL)	234 (84.8)	
IFG (100-126 mg/dL)	39 (14.1)	
Diabetes (≥ 126 mg/dL)	3 (1.1)	
Total Cholesterol		143.0 (21.32)
Normal (≤ 170 mg/dL)	250 (90.6)	
Borderline (170-200)	23 (8.3)	
Above normal (≥ 200)	3 (1.1)	
A1c (%)		6.09(1.33)
Normal (≤ 6.5)	202 (73.2)	
Risk (≥ 6.5)	74 (26.8)	
Blood Pressure		
Systolic		116.8 (16.23)
Diastolic		69.9 (10.9)
Normal (< 90th Percentile)	205 (74.3)	
Pre-hypertensive (90th-95th Percentile)	24 (8.7)	
Hypertensive (>95th Percentile)	47 (17.0)	
Physical Activity		2.20 (0.60)
Low (PA <2 X/wk)	107 (38.8)	
High (PA >2 X/wk)	169 (61.2)	

Table 1: Distribution of variables for sample (N=276).

Logistic regression and cross-tabulation of the individual selected risk factors (levels of A1c, FBG, TC, BP, and WC) indicated that PA was not significantly related to any of the individual metabolic risk factors (Table 2). Figure 2 compares the number of risk factors with high versus low levels of PA. In this comparison, all five risk factors were included. Of the twenty-five subjects who had 3 risk factors, 11 (44.0%) were physically active. Nine subjects presented with four of the five risk factors. Among them, five were physically active, which showed that subjects were at risk for METS regardless of physical activity (Table 2 and Figure 2).

We further compared participants' risk for METS based on the IDF's classification which specified mandatory inclusion of WC and any other two risk factors (Figure 3). With this classification, 19 subjects compared to 25 under the NCEP-ATP III standards presented with 3 risk factors including WC. Nine subjects also presented with 4 of the 5 risk factors including WC. Overall, using the IDF's classification with the mandatory inclusion of WC resulted in 28 subjects being classified with METS compared to 34 using the NCEP-ATTP III standards (Figure 3).

Determination of the metabolic syndrome

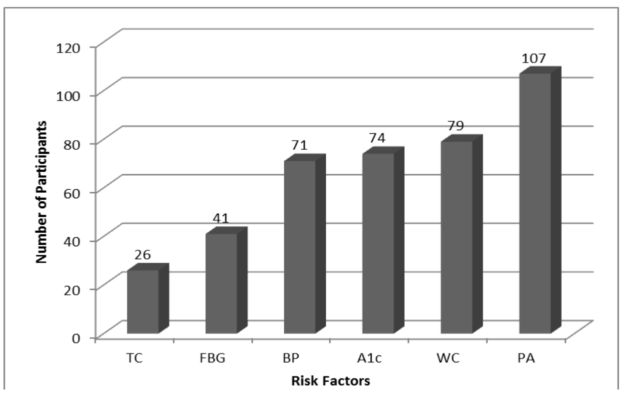
Because both FBG and A1c measured glycemic control, we further analyzed the data by modifying the 5 risk factors that were used to determine the presence of METS (Figure 4). Group A consisted of high FBG, TC, A1c, WC and BP, group B excluded A1c from the analyses whereas Group C excluded FBG. Groups B1 and C1 further classified subjects at risk for METS if they had ≥ 3 risk factors from groups B and C and included high WC. Exclusion of A1c from the total number of risk factors (Figure 4, Group B) reduced the presence of METS in 14 subjects, whereas removal of FBG from the analysis (Figure 4, Group C) resulted in 11 fewer subjects presenting with METS.

With these fluctuations in numbers of subjects at risk for METS, we further used the IDF's classification, which mandates the inclusion of WC and any two other selected risk factors. Groups B1 and C1 represents the presence of ≥3 risk factors and included high WC (Figure 4). When we removed A1c from the numbers of risk factors and included WC (Group B1), 6.9% of the subjects were classified with METS compared to 7.3% when WC was not included. Similarly, removal of FBG and inclusion of WC (Group C1) resulted in 8.0% of the subjects being classified with METS, a reduction of 0.3% (Figure 4).

Table 3 represents Chi Square analyses of subjects' risk for METS based on gender, ethnicity, place of residence, and household income. For these analyses, the researchers manipulated the risk factors by removing A1c and FBG in some instances. Significance (p=0.045) was found only for group C1 and ethnicity. C1 represents the inclusion of A1c and WC. A high number of subjects (n=74) had high A1c levels and high WC (n=79) (Figure 1). It is therefore likely that more subjects would qualify as having 3 or more risk factors for this group. A significantly (p<0.05) higher number of Blacks compared to non-Blacks were classified with METS using the IDF's standard. Gender and place of residence approached significance (p=0.058 and p=0.059, respectively) using this IDF's classification for C1 which excluded FBG but made inclusion of WC mandatory (Table 3).

Comparison of physical activity and individual metabolic risk factors by demographic and environmental variables

Significant differences were noted for some METS risk factors and PA levels using the NCEP-ATP III criteria for determining METS. Logistic regression analyses of PA with each individual risk factor by



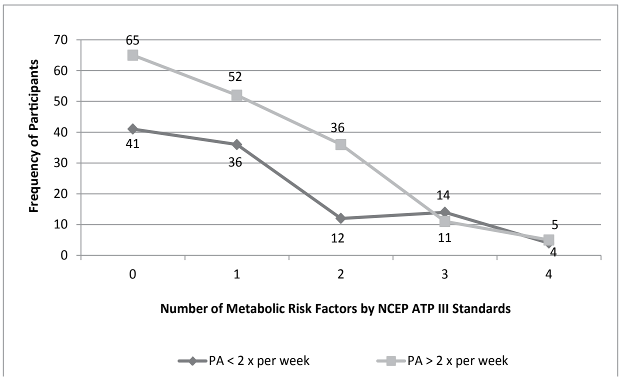
Note: Bars represent number of subjects classified as physical inactive and at high risk for METS based on each metabolic risk factor
Legend: TC = total cholesterol FBG= fasting blood glucose BP= blood pressure A1c = glycated hemoglobin WC = waist circumference PA = physical activity

Figure 1: Frequency of the risk factors.

Metabolic Syndrome Risk Factors	Physical Activity					
	No Risk (n)	Risk (n)	OR	95% CI	r	P value[a]
WC (cm)			0.11	0.623 to 1.93	0.020	0.744
No Risk (n)	120	74				
Risk (n)	49	33				
FBG (mg/dL)			0.63	0.362 to 1.48	-0.047	0.388
No Risk (n)	141	93				
Risk (n)	28	14				
TC (mg/dL)			0.15	0.484 to 2.715	0.023	0.756
No Risk (n)	154	96				
Risk (n)	15	11				
A1c (%)			1.43	0.824 to 2.457	0.072	0.206
No Risk (n)	128	74				
Risk (n)	41	33				
Blood Pressure (mmHg)			0.022	0.499 to 1.651	-0.009	0.751
No Risk (n)	125	80				
Risk (n)	44	27				
TOTAL	169	107				

[a]No significant relationships at $P \leq 0.05$
WC = waist circumference FBG= fasting blood glucose TC = total cholesterol
A1c= glycated hemoglobin BP = blood pressure OR= odds ratio

Table 2: Cross tabulations of individual metabolic risk factors with physical activity (N=276).



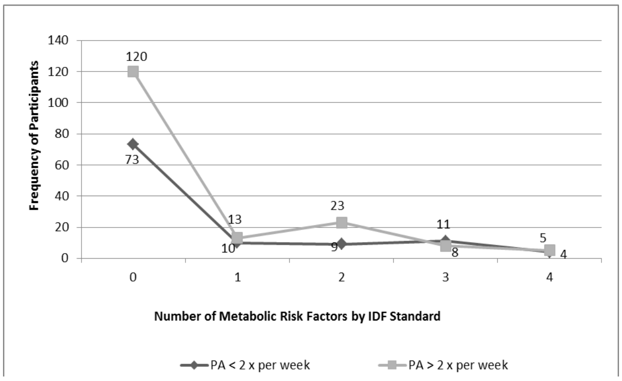
High versus low physical activity are compared with all five metabolic risk factors. The numbers of METS risk factors increased for both low and high physical activity levels. Thirty-four subjects had 3 or more metabolic risk factors. Nine subjects had four of the five metabolic risk factors, of this number, 5 were classified as physically active

Figure 2: Description of Self-reported Frequency of Physical Activities and Number of Metabolic Risk Factors by NCEP Standard, in Jamaican Adolescents (N=276).

gender, ethnicity, place of residence, and household income (Table 4) revealed significant differences by gender for FBG (p=0.040), WC (p=0.041) and PA (p<.001). Females were nearly twice as likely as males to have higher WC and were over 15 times less likely to be physically active than males. Conversely, males were twice as likely to have high FBG compared with females. There were no differences in PA or any of the individual METS risk factors based on ethnicity. Significance was found for place of residence and high WC (p=0.021), and place of residence and low physical activity (p=0.022). Urban subjects were nearly twice as likely to have higher WC as were rural subjects; however, rural subjects were 5 times more likely to be physically inactive compared with their urban counterparts. Subjects from the lower income group were nearly 4 times more likely to be classified with high TC. High A1c and BP were not significantly different based on any of the demographic factors or PA (Table 4).

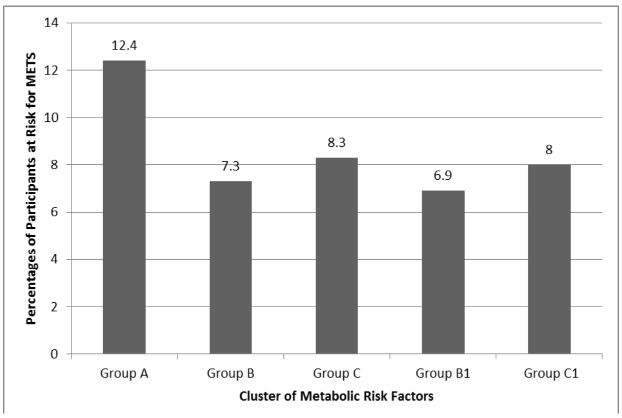
Discussion

We expected similar results on the prevalence of physical activity and metabolic syndrome as found in other adolescent studies [5,28]. Prevalence of 3.5% and 4.7% METS was found in American adolescents using the combined data of the National Health and Nutrition Examination Survey 1999 and 2002 [5,28], respectively. The current study of Jamaican adolescents found point prevalence of 6.9% -12.4% of subjects classified with METS, compared with Ferguson and colleagues' findings of 1.2% [15] among Jamaican adolescents.



Participants were classified at risk for METS if they had high WC and any two other factors (high FBG, TC, A1C, and BP). 27 participants were classified with METS based on this standard. Lower than the numbers classified with METS using the NCEP ATP III standard

Figure 3: Description of Self-reported Frequency of Physical Activities and Number of Metabolic Risk Factors by IDF Standard, in Jamaican Adolescents (N=276).



Group A = FBG, TC, WC, BP, A1c Group B = FBG, TC, WC, BP Group C = TC, WC, BP, A1c
B[1] = A1c excluded from analysis but WC was compulsory for inclusion in the three risk factors
C[1] = FBG excluded from analysis but WC was compulsory for the inclusion in the three risk factors
Note: No Risk = < 3 metabolic risk factors Risk = ≥ 3 metabolic risk factors

Figure 4: Comparison of Number of Metabolic Risk Factors by Groups (N=276).

Presence of Metabolic Risk Factors	Gender			Ethnicity			Place of Residence			Household Income		
	Male (n= 112) n(%)	Female (n= 164) n(%)	P value	Blacks (n=215) n(%)	Non- Blacks (n= 61) n(%)	P value	Urban (n= 140) n(%)	Rural (n= 136) n(%)	P value	High (n= 91) n(%)	Low (n= 184) n(%)	P value
Group A	13(11.6)	21(12.8)	.060	27(12.6)	6(9.8)	.059	18(12.8)	16(11.8)	.060	10(10.9)	24(13.0)	.059
Group B	9(8.0)	11(6.7)	.060	16(7.4)	3(4.9)	.056	13(9.3)	7(5.1)	.060	6(6.6)	14(7.6)	.060
Group C	8(7.1)	15(9.1)	.060	19(8.8)	3(4.9)	.056	13(9.3)	10(7.3)	.060	8(8.8)	15(8.1)	.059
B[1]	9(8.0)	10(6.1)	.061	15(6.9)	3(4.9)	.055	12(8.6)	7(5.1)	.059	6(6.6)	13(7.1)	.060
C[1]	7(6.2)	15(9.1)	.058	19(8.8)	2(3.3)	.045*	13(9.3)	9(6.6)	.059	9(9.8)	13(7.1)	.063

P< 0.05 was significant

Group A = FBG, TC, WC, BP, A1c Group B = FBG, TC, WC, BP Group C = TC, WC, BP, A1c

B[1]= A1c excluded from analysis but WC was compulsory for inclusion in the three risk factors

C[1]= FBG excluded from analysis but WC was compulsory for the inclusion in the three risk factors

n = number of metabolic risk factors ≥ 3

Table 3: Cross-tabulation of the number of metabolic risk factors, with gender, ethnicity, place of residence, and income of Jamaican adolescents (N=276).

Metabolic Risk Factors	Gender			Ethnicity			Place of Residence			Household Income		
	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value
High FBG (>100 mg/dL)	2.01	1.03-3.93	.040 *	0.86	0.37-2.0	.729	0.81	0.42-1.6	.555	0.92	0.53-2.21	.829
High TC (> 170 mg/dL)	0.61	0.25-1.5	.281	0.36	.07-1.45	.141	1.20	0.52-2.78	.674	3.70	1.06-12.8	.039*
High WC[a] (cm)	1.79b	0.32-0.97	.041 *	0.88	0.46-1.69	.708	1.90	1.1-3.2	.021*	0.79	0.45-1.37	.398
High A1c (%)	1.87	-0.04 -0.22	.169	1.56	-0.18-0.04	.204	3.16	-0.25-0.01	.076	.522	-0.17-0.08	.468
High BP (>95[th] Percentile)	0.37	-0.09-0.18	.539	0.59	0.06-0.07	.446	0.31	-0.17-0.09	.579	.118	-0.17-0.15	.732
Low PA (< 2 x/week)	15.47	0.21-0.62	<.001***	0.74	0.66-2.25	.389	5.27	0.35-0.95	.022 *	0.08	0..66-1.98	.787

*p < 0.05 ** p < 0.01 *** p < 0.001 were significant

[a]High WC (≥ 94 cm male, ≥ 80 cm female)

[b]Odds ratio inverted [1.0/0.56]

FBG = fasting blood glucose TC = total cholesterol WC = waist circumference

PA = physical activity A1c= glycated hemoglobin BP = blood pressure

Table 4: Cross-tabulation of the individual metabolic risk factors, and low physical activity with gender, ethnicity, place of residence, and income of Jamaican adolescents (N=276).

Higher prevalence among this sample may be related to our criteria for determining METS. We used a modified version of the NCEP-ATP III as well as the IDF's standard, whereas Ferguson et al. [15] used the IDF's cut-offs for the components of the METS (high WC, BP, IFG, TG, and low HDL-C). The IDF emphasized the presence of central adiposity as a requirement for METS along with any other two measures. In the current study, the presence of any three of the five components; high FBG, WC, BP, A1c, and TC also were used to determine the presence of METS with and without a mandatory criterion of high WC. A higher percentage (12. 4%) of subjects was classified with METS when NCEP-ATP III standards were used. Further, A1c and FBG are both measures of glycemic control, and both were used in our study, which might have resulted in a higher prevalence (12.4%) of METS compared to other studies [5,15,28] using other determinants of METS. Further, total cholesterol, rather than triglycerides and high-density lipoprotein cholesterol, were measured in the current study. Our determination of METS was obtained from secondary data which did not include the specific criteria for the NCEP-ATP III standards (high FPG, LDL-C, BP, WC and low HDL-C). This may have inflated the percentage of Jamaican adolescents who presented with METS.

Low PA did not predict the metabolic risk factors in our study, but statistical significance was found for PA and both gender and place of residence. Contrary to other studies on PA and the individual risk factors for METS [5,10] which found that low PA is related to more risk factors for METS, we found no significant relationship between PA and any of the individual METS risk factors.

The inability of PA to predict the risk factors in our study may be related to the scale used to classify subjects' physical activity as well as measures used to determine METS. The majority of the subjects in our study were classified as physically active if they engaged in any form of PA more than two times per week. The criteria used to determine high versus low PA might not have been a sufficiently robust measurement to elicit significant relationships between PA and the individual METS risk factors or combinations of METS risk factors. Similarly, our criteria for determining METS represented a modified version of the NCEP-ATP III [21] and the IDF's criteria [23].

In an earlier study [29], adolescent males presented with one or more risk factors than did adolescent females, especially if the males were overweight or obese. In the present study, adolescent females and males had equal numbers of risk factors for METS regardless of what classification for METS was used, but females were 15 times more likely to be less physically active than males (p=0.001). These results on gender and risk for METS contradicted earlier findings of higher prevalence of METS among male adolescents in US based studies [5,28]. Jamaican female adolescents' risk for METS is likely related to their higher WC. In this study, females had higher waist circumferences than did males and this difference was statistically significant. High waist circumference was one of the criteria for determining the presence of METS under the IDF's classification.

As expected, a significantly higher percentage of Blacks had three or more risk factors for METS, compared with non-Blacks, under IDF's criteria. These findings may be due to the higher number of Blacks in this population, since Jamaica's population comprises 91% Blacks compared with other ethnicities. In the current study, non-Blacks include Indians, Chinese, and mixed ethnicities (subjects from inter-racial unions). Despite the fact that Blacks were more likely to have three or more of the risk factors for METS, ethnicity was not significantly related to any of the individual metabolic risk factors or with PA.

We found no significant relationships for A1c or BP with gender, ethnicity, place of residence or household income. Although 26% of subjects were classified with high A1c, no significance was found for at risk subjects in terms of demographic or environmental characteristics. Similarly, the majority of subjects had normal BP (<90th percentile) which classified them as low risk for METS. Contrary to our expectations, subjects from low income households had significantly higher TC than those with higher incomes. Dietary intake of cholesterol is associated with intake of foods from animal origin such as meat, fish, milk and eggs. Such foods are less affordable to low income families. Higher levels of TC among lower income subjects may be related to their body's metabolism of cholesterol. Cholesterol is manufactured by the liver and is present in the body regardless of dietary intake [30]. Diets which are low in fiber have been associated with higher levels of cholesterol in the blood [31]. Fibers trap bile acids and eliminate them from the body (new 31). There is research evidence that Jamaicans do not get their recommended daily intakes of fruits and vegetables [32]. Further analysis of subjects' fiber intakes is warranted.

Although low PA did not predict metabolic risk factors in our study, there is still a growing concern, especially for adolescents who reside in rural Jamaica that their low PA may lead to being overweight. Overweight has been linked to the development of risk factors associated with METS in later years [1,2]. Based on previous research [11,12] that showed association of decreased PA levels with higher intakes of energy-dense foods among urban adolescents, we expected urban adolescents to have greater number of risk factors for METS than their rural counterparts. Our findings suggested that urban subjects had higher WC than did rural subjects (p=0.021), but no higher risk for METS compared with their rural counterparts, despite being more physically active. Closer examination of the data revealed that urban subjects participated in more team sports (data not shown) than did the rural subjects which accounted for their higher PA levels. Females were found to be less physically active than males in this study. We believe this might be related to the kinds of activities that were used to determine physical activity among this population. Many of the activities were more likely to be engaged in by Jamaican males when compared to Jamaican females who tend to undergo more parental restrictions and are usually trained to be more domesticated.

Strengths and Limitations of the Study

This study, to our knowledge, was the first of its kind to examine Jamaican adolescents' risk for METS in relation to the frequency of physical activities. Limitations of the study include recall and instrumentation biases. Firstly, PA was measured by having students recall all the physical activities they performed in the past week, as well as how many times per week those activities were performed. It is likely that some errors may have been introduced in recalling this information. Secondly, the instrument used for measuring PA did not include the time spent, or the amount of energy expended on each activity, but it provided useful information on the types of activities in which Jamaican adolescents were engaged. The majority of subjects listed dancing as their most engaged activity followed by walking (data not shown). This information will help guide intervention programs.

Other limitations included the criteria used for measuring adolescent WC; adult standards were used which is a criticism of studies that aim to measure WC among adolescents. This association of high WC among adolescents and risk of T2D and CVD requires further investigation. Additionally, the blood measures used in the analyses were not the standard ones used for determining METS. FBG instead of fasting plasma glucose (FPG) was measured. FPG is a better estimate since glucose concentrations in plasma are lower than whole blood [30], whereas, FBG is likely to overestimate glucose concentrations. Further, total cholesterol rather than triglycerides was used in the current study. An earlier study [22] indicated that triglycerides (TG) is a better indicator of dyslipidemia in METS in adolescents than the "lipid triad" which includes high TG, low HDL-C and high LDL-C. Since we used different measures, our criteria represented a modified version of both the NCEP-ATP III and IDF standards. Our measures, though can serve as an early warning sign of metabolic risks for the initiation of prevention efforts.

Recommendations

Further studies are needed to verify risk factors for METS among Jamaican adolescents. Identification of the lifestyle factors related to METS may help to prevent the development of chronic diseases in adulthood. A more rigorous method of classifying PA levels, duration and amount of energy expended are suggested for future studies. For our study, we selected blood measures that were economical and could be easily performed among adolescents within a school setting. For future studies, use of TG or FPG is recommended.

Conclusion

Jamaican adolescents are at risk for METS irrespective of the frequency of physical activity. Females and rural subjects were less physically active than their male and urban counterparts but no more likely to be at risk for METS using the NCEP=ATP III standard. The number of metabolic risk factors varied depending on the classification used for determining METS. The IDF's criterion identified 6.9% of the adolescents at risk for METS whereas the modified version of the NCEP-ATP III classification found a prevalence of 12.4% subjects having ≥ 3 risk factors for METS. A higher percentage of subjects were classified with having ≥ 3 risk factors when A1c, instead of FBG was selected as the criterion for measuring glycemic control. However, it must be noted that the number of subjects classified with high A1c was twice as high as those with high FBG in our study. Consequently, the inclusion of A1c and WC in determining the presence of METS resulted in Blacks having significantly higher number of risk factors ≥3. No other significance was found using the IDF's standards, but gender and place of residence approached significance. Although no significance was found between PA and the individual METS risk factors, being female and living in urban areas were associated with low PA. The lack of association between PA and the METS risk factors may be due to the measures used for determining high versus low PA. Subjects were considered to be physically active as long as they engaged in physical activities 2 or more times per week which classified the majority of subjects as being physically active. Future interventional studies are needed to examine the effect of physical activity on reducing the risk factors for METS.

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Conflict of Interest

The authors declare no conflict of interest.

Author Contribution

1. **Sheila Barrett:** Conceptualization of project, research design, funding

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of research, data collection and analysis, drafting of manuscript and subsequent editing.

2. **Fatma Huffman:** Conceptualization of project, research design, funding of research, analysis of data, editing of manuscript.

3. **Paulette Johnson:** Conceptualization of project, research design, statistical analysis and interpretation of data, editing of manuscript.

4. **Adriana Campa:** Conceptualization of research methodology, research design, data analysis, editing of manuscript.

5. **Marcia Magnus:** Conceptualization of project, research design, editing of manuscript.

6. **Dalip Ragoobirsingh:** Conceptualization of project, research design, editing of manuscript.

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