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Prevalence of metabolic syndrome and its relationship with leisure time physical activity among Peruvian adults

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Abstract

Background—Metabolic syndrome (MetS) is an important risk factor of cardiovascular disease (CVD) and type 2 diabetes (T2DM). Previous studies have suggested an inverse relationship between physical activity and MetS. However, these findings were inconsistent; and few investigators have examined these associations among South Americans. We estimated the prevalence of MetS and its association with leisure time physical activity (LTPA) among Peruvian adults.

Materials and methods—This cross-sectional study of 1,675 individuals (619 men and 1056 women) was conducted among residents in Lima and Callao, Peru. Information about LTPA, socio-demographic, and other lifestyle characteristics were collected by interview. The presence of MetS was defined using the Adult Treatment Panel III (ATP III) criteria.

Results—Overall, the prevalence of MetS was 26.9% and was more common among women (29.9%) than men (21.6%). Habitual participation in LTPA was associated with a 23% reduced risk of MetS (OR=0.77; 95% CI: 0.60–1.03). There was an inverse trend of MetS risk with amount of LTPA ($p=0.016$). Compared with non-exercisers, those who exercised < 150 minutes/week had a 21% reduced risk of MetS (AOR= 0.79; 95% CI 0.60–1.04). Individuals who exercised $\geq$ 150 minutes/week, compared with non-exercisers, had a 42% reduced risk of MetS (AOR=0.58; 95% CI: 0.36–0.93). Associations of similar magnitudes were observed when men and women were studied separately.

Conclusion—These data document a high prevalence of MetS and suggest an association with LTPA among urban dwelling Peruvians. Further prospective studies are needed to confirm these observations and to examine interventions that may promote increased physical activity in this population.

Keywords

Metabolic Syndrome; Physical Activity; Peru

Background

Chronic diseases accounts for 60% of all deaths globally, more than double the number of deaths caused by infectious diseases, maternal and perinatal conditions, and nutritional

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deficiencies combined [1]. Cardiovascular disease (CVD) is now recognized as the leading cause of morbidity and mortality in developing countries [2]. Metabolic syndrome (MetS), a constellation of metabolic abnormalities, is an important risk factor of CVD and type 2 diabetes (T2DM) (3). Previous studies have suggested an inverse relationship between physical activity and MetS [3–5]. However, these were inconsistent and few have examined these associations among populations outside of North America, Europe and Asia. This gap in literature is particularly evident for South American populations where the prevalence of obesity, and physical inactivity have increased with economic growth and development [6,7] and rapid urbanization [8]. Peru, for instance, has emerged as one South American country that has undergone considerable economic growth and has had concomitant increases in the prevalence of CVD risk factors [7]. To date, we are aware of only four studies documenting the prevalence of MetS among Peruvians [6,9–11]. However, to the best of our knowledge, there are no published reports that evaluated the relationship between physical activity and MetS in Peru.

In light of the increasing burden of CVD in developing countries [12], increases in the prevalence of CVD risk factors such as physical inactivity and obesity, and the scarcity of cardiovascular epidemiology studies conducted among South Americans, we estimated the prevalence of MetS and its association with leisure time physical activity (LTPA) among Peruvian adults. Results from our study will help in developing evidence-based health promotion and disease prevention programs that are relevant to South American population.

Materials and methods

Design and Participants

Study subjects were Peruvian men and women who participated in the Prevalencia de Factores de Riesgo de Enfermedades No-Transmisibles (Prevalence of Risk Factors for Non Transmissible Diseases) referred to as the FRENT study. The primary objective of the FRENT study was to determine the prevalence and risk factors associated to non-transmissible diseases among residents in Lima and Callao, Peru. Investigators used a multistage, probabilistic stratified sampling strategy to identify and recruit participants for the study. Using maps of Lima and Callao, investigators grouped the 31 metropolitan districts of Lima in five strata based on their economic profiles. A three-stage sampling strategy was then implemented within each strata. Briefly, within each strata, blocks were selected at random (stage 1), then households were selected at random from blocks; and finally after household census were taken, one member of each sampled household was randomly selected to participate in an in-person interview and medical exam. Individuals < 15 years of age, those who reported less than 12 month residence status in Lima, and women who were pregnant at the time of sampling were ineligible for inclusion in the FRENT study. Approximately 71% of individuals who were invited to participate in the study elected to do so. For the study described here, we excluded subjects < 18 years of age. The final analyzed sample included 1,675 individuals (619 men and 1056 women) FRENT study participants after the exclusion of 96 participants.

Data Collection and Variable Specification

Each participant was interviewed by a trained interviewer using a structured questionnaire validated by the Pan American Health Organization (PAHO) for assessing the prevalence of non transmissible disease (NTD) risk factors [13]. The questionnaire inquired about individuals' participation in leisure time physical activity during a typical week. Participants were queried about the number of days per week they engaged in moderate physical exercise (e.g., riding a bicycle or swimming at a leisurely pace) and the amount of time engaged in such activities each week. Information about age, gender, educational attainment, and

medical history was also obtained via in-person interviews. Height and weight were measured with participants wearing light clothing and no shoes. Waist circumference was measured from the midpoint between the iliac crest and the lower ribs measured at the sides. Hip circumference was measured at the point of the maximum circumference over the buttocks. After participants had been seated for at least 5 minutes, and again after 30 minutes during the interview a resting blood pressure was measured using a Mercury Desk Sphygmomanometer, these two values were averaged. A follow-up visit to participants' home was made the next morning to collect a blood sample after a 12-hour fast. Aliquots of serum were used to determine participants' fasting glucose concentrations and lipid profiles. Serum triglycerides (TG), total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), glucose, and insulin were measured at the Peruvian National Institute of Health Laboratory in Lima, Peru. TG concentrations were determined by standardized enzymatic procedures using glycerol phosphate oxidase assay. HDL-C was measured by a chemical precipitation technique using dextran sulfate. Participants' fasting serum glucose (FSG) was determined using standardized glucose oxidase method (glucose oxidase GOD-PAP). All laboratory assays were completed without knowledge of participants' medical history. Lipid, lipoprotein and FSG concentrations were reported as mg/dl.

For the present analysis, participants were classified as being engaged in LTPA (yes vs. no). Those who were engaged in LTPA were further classified as having inadequate or adequate amount of weekly exercise. Inadequate and adequate weekly exercise categories were created in accordance with the recommendation by the US Centers for Disease Control and Prevention (CDC), the American College of Sports Medicine (ACSM), the American Health Association (AHA), and the 1996 US Surgeon General's Report on Physical Activity and Health. Briefly these organizations recommend that individuals participate in at least 30 minutes of modest physical activity, most if not all, days of the week [14–16]. Total minutes per week spent engaging in LTPA were classified in to three categories using cut-points used previously [17]: (1) no exercise (0 min/week), (2) inadequate LTPA (< 150 minutes/week), and (3) adequate LTPA (>150 min/wk). Body mass index (BMI) was calculated as kg/m^2 . Overweight and obesity were defined as a participant with BMI between 25–29.99 kg/m^2 and $\geq 30 \text{ kg/m}^2$, respectively. In accordance with the Adult Treatment Panel III (ATP III) of the National Cholesterol Education Program [18,19] MetS was defined when three or more of the following attributes were present: 1) mean value of systolic blood pressure (SBP) $\geq 130 \text{ mmHg}$, mean value of diastolic blood pressure (DBP) $\geq 85 \text{ mmHg}$; 2) abdominal obesity (waist circumference $> 102 \text{ cm}$ in men and $> 88 \text{ cm}$ in women); 3) low HDL-C ($< 40 \text{ mg/dl}$ in men and $< 50 \text{ mg/dl}$ in women); 4) TGs $\geq 150 \text{ mg/dl}$; 5) FSG $\geq 100 \text{ mg/dl}$ or current anti-diabetic medication use [20].

All subjects provided informed consent and all research protocols were approved by the Institutional Review Boards of National Institute of Health in Peru, Dos de Mayo Hospital, Peru and the Human Subjects Division at the University of Washington, USA.

Statistical Analyses

We first explored frequency distributions of socio-demographic, clinical and behavioral characteristics of subjects. Continuous variables were expressed as mean $\pm$ standard error of means (SEM). Categorical variables were expressed as number (percent, %). Chi-Square tests were used to evaluate differences in the distribution of categorical variables for study groups. Student's *t* tests were used to evaluate differences means for study groups. Logistic regression procedures were used to estimate odds ratios (OR) and confidence intervals (CI) of MetS according to differing levels of LTPA. Confounding factors were evaluated on the basis of their hypothesized relationship with variables representing LTPA (e.g., the dichotomous LTPA variable [yes/no]; or level of exercise [none/inadequate/adequate weekly

exercise]. In multivariate analysis, tests for linear trend across increasing categories of LTPA were conducted by treating the three-level LTPA variable as a continuous variable [21]. Confounding was assessed by entering potential covariates into a logistic regression model one at a time, and by comparing the adjusted and unadjusted ORs. Final logistic regression models included covariates that altered unadjusted ORs by at least 10% [21]. Logistic regression analyses were repeated for men and women separately. All statistical analyses were performed using SPSS (version 14.0, SPSS Inc. Chicago, IL, USA) software. All reported p-values are two tailed and confidence intervals were calculated at the 95% level.

Results

Metabolic characteristics of the study population are summarized in Table 1. Overall, the prevalence of MetS was 26.9% and was more common among women (29.9%) than men (21.6%). The mean systolic blood pressure was higher for men than for women. Men had higher abdominal obesity (i.e., waist circumference) as compared with women. Fasting serum glucose concentrations were similar for both groups. TC, HDL-C, and LDL-C concentrations were higher, on average, for women as compared with men. However, mean TG concentrations were higher among men than women.

The prevalence of each component of MetS is summarized in Figure 1. Reduced HDL-C (61.1%) and abdominal obesity (53.3%) were the most common MetS components among women; whilst reduced HDL-C (46.0%) and elevated TG concentrations (39.3%) were most common among men. Abdominal obesity was far less common among men as compared with their female counterparts (17.0% vs. 53.3%). Figure 2 shows the presence of 0, 1, 2, 3, 4 and 5 components of MetS among men and women. Overall, women had increased numbers of MetS components compared with men.

Women with MetS, as compared with those without the syndrome were older ($p<0.001$) and less well educated ($p<0.001$) (Table 2). Men with MetS, as compared with their counterparts without the syndrome, were older ($p<0.001$), less well educated ($p<0.001$), were more likely to have ever smoked cigarettes ($p=0.031$), and were less likely to report habitual engagement in adequate levels of LTPA ($p=0.05$).

Habitual participation in LTPA was associated with a 23% reduced risk of MetS (OR = 0.77 95%CI: 0.60–0.98) (Table 3). The association was attenuated slightly after adjustment for age, education, smoking status and gender (AOR = 0.79; 95% CI: 0.60–1.03), and became insignificant. There was an inverse trend of MetS risk with amount of LTPA (p-value for linear trend=0.016). Compared with non-exercisers, those who exercised <150 minutes/week had a 21% reduced risk of MetS (AOR = 0.79; 95% CI 0.60–1.04). Individuals who exercised ≥ 150 minutes/week, compared with non-exercisers, had a 42% reduced risk of MetS (AOR = 0.58; 95% CI: 0.36–0.93). Associations of similar magnitudes were observed when men and women were studied separately.

Discussion

The results of this study confirm and expand the literature in multiple ways. First, study findings confirm a high prevalence of the syndrome (26.9% overall). Second, to the best of our knowledge, this is the first reported examination of the association between the prevalence of MetS and LTPA among Peruvians. Habitual participation in LTPA was associated with a 21% reduced risk of MetS and we noted an inverse trend of MetS risk with amount of LTPA ($p=0.016$). Individuals who exercised ≥ 150 minutes/week, compared with non-exercisers, had a 42% reduced risk of MetS (AOR = 0.58; 95% CI: 0.36–0.93).

Associations of similar magnitudes were observed when men and women were studied separately. These findings have important public and clinical implications as populations in developed and developing countries, like Peru, experience new challenges with the obesity epidemic.

Few studies have investigated the prevalence of MetS among South Americans. We are aware of only four published reports documenting the prevalence of MetS among Peruvians [9–11,22]. Soto et al, in their cross sectional study of adults in the Lambayeque, a northern district of Lima, reported prevalence estimates of 29.9% among women and 23.1% among men [11]. More recently, Medina-Lezama *et al*, recently reported prevalence estimates of 23.2% among women and 14.3% among men who reside in Arequipa, the second largest city in Peru. [9]. These estimates were largely corroborated by Lorenzo et al, who reported MetS prevalence estimates of 25.6% and 11.5% among female and male residents of low-income coastal districts in Lima [22]. MetS prevalence estimates from our population-based sample of Peruvians residing in Lima and Callao (29.9% for women and 21.6% for men) are largely similar to those reported by Soto et al [11]. Differences in estimated MetS prevalence across studies may be attributed to variations in population characteristics, sampling strategies, methods of data collection, and diagnostic criteria used for across studies [9].

Our observations of inverse associations of MetS with LPTA are consistent with some [23–26], though not all [3,27] previous reports. Ford *et al*, in their cross-sectional study of US adults reported an inverse trend of MetS among men and women who exercised [17]. The magnitude of observed associations in their study and our present study are comparable with the magnitude of associations reported in prospective cohort studies [23,28]. Over the last years, Peru has seen an increased epidemiological and nutritional transition that changed the morbidity and mortality profile of the country [12]. This is in part due to the rapid urbanization which is accompanied by the increased access to energy-dense industrialized foods [29] and technological changes that lead to reduced physical activity [30]. Although a large body of evidence has clearly demonstrated that physical inactivity as an important modifiable risk factor for MetS among populations in North America and Europe [4,5], data regarding the relation between physical activity and MetS is nonexistent in Peru. Ramirez-Vargas and colleagues in their study among male adults in Oaxaca, Mexico reported that physical activity as an independent protective factor of MetS (OR=0.40 95%CI p<0.001) [25]. Similarly Sofi *et al* in Italy reported a statistically significant association between leisure time physical activity and MetS components (P<0.05) [26]. Ma *et al* in their national survey among employed populations in China reported a significantly reduced risk of metabolic syndrome with increased physical activity [4]. Oguma and Shioda-Tagawa [5], in their meta-analysis of 23 studies conducted in industrialized countries, reported a significant reduction risk of CVD with physical activity among women. Furthermore, the investigators noted that inactive women would benefit by even slightly increasing their physical activity which could be walking 1 hour per week or less [5]. Our findings and those of others, however, are dissimilar to reports from other teams of investigators [3,27]. For instance, Dalacorte *et al*, in their study of elderly Brazilians reported no associations of MetS with physical activity [3]. Despite differences in study subject characteristics and operational definitions of leisure time physical activity, our study results are in agreement with these previous reports that showed physical activity to be an important protective factor for MetS [4,5,25,26].

Strengths of our study include the extensive CVD risk-factor data available for study participants, and the unique opportunity to assess these risk factors in a population-based sample representative of adult residents of Lima, Peru. Limitations of our study include the cross-sectional design, which precludes our ability to define the temporal relation between

participants' habitual LPTA and incident MetS. Additionally, physical activity was based on self-report and thus is subject to errors and is less accurate than objective measures of physical activity (e.g., by accelerometers[31] or cardio-respiratory fitness[32]). Objective measures of physical activity and cardio-respiratory fitness, however, are difficult to obtain in large population-based epidemiological studies [26]. Concordance of findings from studies using self-reported physical activity measures with those that assessing physical activity using direct measures serve to attenuate some concerns about measurement error.

Results from observational epidemiologic studies [23–26] and from randomized trials [33,34] have consistently demonstrated an inverse relationship between physical activity and MetS. The observed statistical association in our study and those reported by other investigators are biologically plausible. As hypothesized by several investigators, abdominal obesity and insulin resistance are believed to be the primary physiological mechanisms for development of MetS [35,36]. Changes in life style have shown to reduce insulin resistance and obesity. Among modifications in lifestyle, an increase in physical activity plays an important role[36].

In conclusion, the prevalence of MetS observed in this study was high and engaging in LTPA was associated with decreased risk of MetS. Research has shown that MetS is associated with an increased risk of diabetes and cardiovascular disease-related morbidity and mortality, resulting in an enormous economic burden to society [37]. Investigators in Latin America have called for a country-specific epidemiologic data to help bring public health policy changes for surveillance, prevention, and intervention [6]. The high prevalence of MetS reported in this study calls for clinical preventive services to identify and control the existing metabolic abnormalities among patients. Moreover, development and implementation of public health programs that promote physical activity and balanced diet are needed to help reduce the burden of disease.

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Figure 1. Prevalence of Each Component of Metabolic Syndrome

*Metabolic syndrome components: 1) mean value of systolic blood pressure (SBP) ≥ 130 mmHg, mean value of diastolic blood pressure (DBP) ≥ 85 mmHg; 2) abdominal obesity (waist circumference >102 cm in men and >88 cm in women); 3) low HDLC (< 40 mg/dl in men and < 50 mg/dl in women); 4) TGs ≥ 150 mg/dl; 5) FSG ≥ 100 mg/dl or current anti-diabetic medication use.

Figure 2.
Number of Metabolic Syndrome components by gender

Table 1

Clinical and Metabolic Characteristics of the Study Population, Lima, Peru 2006

Characteristics	Women (N=1056)	Men (N=619)	*P-Value
	n (%)	n (%)	
BMI (Kg/m²)			
Underweight (<18.5)	9(0.9)	12(1.9)	<0.001
Normal (18.5 – 24.9)	438(41.5)	231(37.3)	
Overweight (25.0 – 29.9)	374(35.4)	272(43.9)	
Obese (>30.0)	235(22.3)	104(16.8)	
Metabolic Syndrome			
No	740(70.1)	485(78.4)	<0.001
Yes	316(29.9)	134(21.6)	
	Mean ±SE	Mean ± SE	
Waist Circumference(cm)	89.2 ± 0.4	92.4 ± 0.4	<0.001
Hip circumference (cm)	99.9 ± 0.4	99.0 ± 0.3	0.064
Total cholesterol (mg/dL)	188.1 ± 1.3	181.6 ± 1.6	0.002
HDL cholesterol (mg/dL)	48.5 ± 0.4	42.7 ± 0.4	<0.001
LDL cholesterol (mg/dL)	118.8 ± 1.0	115.2 ± 1.3	0.035
Triglycerides (mg/dL)	131.8 ± 2.8	155.3 ± 4.1	<0.001
Fasting glucose (g/dL)	90.1 ± 0.9	90.1 ± 1.0	0.778
Systolic blood pressure (mmHg)	115.1 ± 0.5	121.1 ± 0.6	<0.001
Diastolic blood pressure (mmHg)	72.1 ± 0.3	76.1 ± 0.4	<0.010

* P-value from Chi-Square test for categorical variables or from Student's t-test for continuous variables.

Table 2
 Characteristics of the Study Population According to Metabolic Syndrome, Lima, Peru 2006

Characteristics	Among Women				Among Men			
	Metabolic Syndrome				Metabolic Syndrome			
	No (N = 740)	Yes (N = 316)			No (N = 485)	Yes (N = 134)		
	n	%	n	%	n	%	n	%
Age (Years)								
≤ 24	149	20.1	5	1.6	132	27.2	4	3.0
25–34	206	27.8	36	11.4	128	26.4	21	15.7
35–44	182	24.6	66	20.9	85	17.5	27	20.1
45–54	111	15.0	77	24.3	56	11.5	36	26.9
55–64	54	7.3	76	24.1	42	8.7	28	20.9
≥ 65	38	5.2	56	17.7	42	8.7	18	13.4
Education[†]								
≤ 6 years	100	14.0	91	29.4	50	10.6	20	15.3
7–12 years	343	48.0	132	42.6	240	50.8	43	32.8
> 12 years	272	38.0	87	28.1	182	38.6	68	51.9
Ever smoked								
No	627	84.7	259	82.0	279	57.5	63	47.0
Yes	113	15.3	57	18.0	206	42.5	71	53.0
Current smoker								
No	670	90.5	283	89.6	337	69.5	88	65.7
Yes	70	9.5	33	10.4	148	30.5	46	34.3
Leisure time physical activity								
No	161	21.8	85	26.9	139	28.7	48	35.8
Yes	579	78.2	231	73.1	346	71.3	86	64.2
Adequacy of leisure time physical activity								
No exercise	161	21.8	85	26.9	139	28.7	48	35.8
Inadequate: <150 min/week	501	67.7	207	65.5	283	58.3	77	57.5
Adequate: ≥ 50 min/week	78	10.5	24	7.6	63	13.0	9	6.7

* P-value from Chi-Square tests

[†] Numbers/percentages may not add up to the total number due to missing data

Table 3

Distributions of Study Participants and Odds Ratios (OR) and 95% Confidence Intervals (95% CI) for Metabolic Syndrome According to Leisure Time Physical Activity, Lima, Peru 2006.

Engagement in Leisure Time Physical Activity (LTPA)	Metabolic Syndrome					
	No (N=1225)			Yes (N=450)		
	N	%	n	%	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
All						
No	300	24.5	133	29.6	1.00 (Reference)	1.00 (Reference)*
Yes	925	75.5	317	70.4	0.77(0.60–0.98)	0.79(0.60–1.03)
<i>Inadequate: <150 min/week</i>	784	64.0	284	63.1	<i>0.81(0.64–1.04)</i>	<i>0.79(0.60–1.04)</i>
<i>Adequate: ≥50 min/week</i>	141	11.5	33	7.3	0.52(0.34–0.81)	0.58(0.36–0.93)
<i>p for trend</i>					0.004	0.016
Among Men						
No	139	28.7	48	35.8	1.00 (Reference)	1.00 (Reference)**
Yes	346	71.3	86	64.2	0.72(0.48–1.07)	0.86(0.55–1.33)
<i>Inadequate: <150 min/week</i>	283	58.3	77	57.5	<i>0.78(0.52–1.19)</i>	<i>0.90(0.57–1.41)</i>
<i>Adequate: ≥50 min/week</i>	63	13.0	9	6.7	0.41(0.19–0.89)	<i>0.61(0.27–1.39)</i>
<i>p for trend</i>					0.027	0.318
Among Women						
No	161	21.8	85	26.9	1.00(Reference)	1.00 (Reference)***
Yes	579	78.2	231	73.1	0.76(0.56–1.02)	0.73(0.52–1.03)
<i>Inadequate: <150 min/week</i>	501	67.7	207	65.5	<i>0.78(0.57–1.06)</i>	<i>0.75(0.53–1.07)</i>
<i>Adequate: ≥50 min/week</i>	78	10.5	24	7.6	0.58(0.34–0.98)	<i>0.63(0.35–1.11)</i>
<i>p for trend</i>					0.031	0.067

* Adjusted for age, education, and gender

** Adjusted for age, education and smoking

*** Adjusted for age and education