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Lack of relationship of physical activity level with cardiovascular risk factors and metabolic syndrome in apparently healthy men

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Abstract
Background: The World Health Report 2002 of the World Health Organization estimated that physical inactivity is one of the 10 main causes of morbidity and mortality and that the proportion of people whose health is at risk due to a sedentary lifestyle is approximately 60%.
Objective: To assess the relationship of physical activity level with cardiovascular risk factors and metabolic syndrome in 61 healthy men.
Methods: The short version of the International Physical Activity Questionnaire (IPAQ) recommended by the World Health Organization was used as a valid measure to estimate two categories of physical activity, low (insufficient and sedentary) and vigorous (moderate and very active). Cardiovascular risk factors and metabolic syndrome were defined using the criteria of the National Cholesterol Education Program of the United States and the International Diabetes Federation respectively. Serum levels of C-reactive protein and ferritin were also measured, and insulin sensitivity was estimated using the Homeostatic Model Assessment-Insulin Resistance (HOMA-IR).
Results: Mean population age was 47.1 ± 6.9 years. Seventeen participants (28%) had metabolic syndrome. There were no differences between the categories of low and vigorous physical activity, nor a relationship with total physical activity (MET x week). No association was observed between low levels of physical activity and metabolic syndrome criteria.
Conclusions: The high prevalence of physical inactivity found in study participants using the IPAQ questionnaire was not associated with cardiovascular risk factors and metabolic syndrome.

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PALABRAS CLAVE
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Hombres;
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Falta de relación entre el nivel de actividad física con marcadores de riesgo cardiovascular y síndrome metabólico en hombres aparentemente sanos

Resumen
Fundamento: El Informe sobre la salud en el mundo 2002 de la Organización Mundial de la Salud estimó que el sedentarismo constituye una de las 10 causas fundamentales de morbimortalidad y que la proporción de la población cuya salud está en riesgo debido a una vida sedentaria se aproxima al 60%.
Objetivo: Evaluar la relación entre el nivel de actividad física (AF) con marcadores de riesgo cardiovascular y síndrome metabólico en 61 hombres aparentemente sanos.
Métodos: Se aplicó la versión corta del International Physical Activity Questionnaire (IPAQ) para estimar la AF en dos categorías: baja actividad física (insuficiente y sedentario) y alta actividad física (moderado y muy activo). Los marcadores de riesgo cardiovascular y síndrome metabólico fueron definidos siguiendo los criterios del ATP-III y de la Federación Internacional de Diabetes, respectivamente. Se tomaron niveles séricos de proteína C reactiva, ferritina y se calculó la sensibilidad a insulina mediante el Homeostatic Model Assesment-Insulin Resistance (HOMA-RI).
Resultados: El promedio de edad de la población fue 47,1 ± 6,9 años. Diecisiete participantes (28%) presentaron síndrome metabólico. No se encontraron diferencias entre las categorías según el cuestionario IPAQ baja o vigorosa AF, ni relación con la AF total (MET x semana). Tampoco asociaciones entre bajo nivel de AF con los criterios de síndrome metabólico.
Conclusiones: Una alta prevalencia de sedentarismo se encontró en los participantes cuando se miden con el cuestionario IPAQ, aunque los niveles de AF no se asociaron con los marcadores de riesgo cardiovascular o síndrome metabólico.

Introduction

Cardiovascular diseases represent the main cause of mortality and account for almost 60% of all deaths and 43% of all diseases worldwide[1]. In the 1980s, Reaven et al noted that dyslipidemia, hypertension, and hyperglycemia were conditions frequently associated in the same individual and involved a greater cardiovascular risk. This condition was called metabolic syndrome (MS). MS is a group of metabolic abnormalities including glucose intolerance, insulin resistance, central obesity, arterial hypertension, and a prothrombotic state. MS has been found in subjects reporting behavior and preferences related to an unhealthy lifestyle including inadequate diet, sedentary lifestyle, alcohol consumption, and smoking.

In addition to already known metabolic markers of cardiovascular risk such as glucose, cholesterol, and triglycerides (TGs), new markers have been studied in the past decades related to the risk of MS and non-transmissible chronic diseases (NTCDs)[3,4]. Subclinical inflammation, as assessed by levels of high-sensitivity C-reactive protein (hs-CRP), and iron deposits based on ferritin levels have been associated with risk of type 2 diabetes and MS[3,4].

The current obesity epidemic and high levels of physical inactivity have doubled the prevalence of MS in overweight US adults in only 10 years (1988-1994 and 1999-2004)[5,6] according to the US National Health and Nutrition Survey. MS prevalence in the United States (NHANES III Study) using the diagnostic criteria of the Third Expert Panel of the National Cholesterol Education Panel (NCEP-ATP III)[7,8] was close to 24% in subjects aged 20 years or older. This definition, using fasting glucose levels ranging from 110 to 125 mg/dL, has been used in many studies. The combined efforts of the International Diabetes Federation (IDF)[9], the US National Heart, Lung, and Blood Institute, and the American Heart Association have resulted in a definition of MS for use in clinical practice worldwide.

This health problem is becoming a critical problem in developing countries, which are highly influenced by modernization and urbanization[10]. Lifestyle changes including reduced physical activity and the replacement of traditional diets by high-fat, high-calorie diets are two explanations for this phenomenon[11]. In addition, age, sex, and genetics are factors with a significant impact on predisposition to MS[9-11].

Several studies have assessed the association of the different characteristics of physical activity, as defined by the international physical activity standard (International Physical Activity Questionnaire or IPAQ), with cardiovascular risk factors and MS but without definitve results[12,13]. The purpose of this study was to assess the relationship of the level of physical activity, as assessed with the IPAQ, to cardiovascular risk factors and MS in apparently healthy males.

Methods

Study population

Sixty-one males aged 25-64 years from the metropolitan area of Cali (Colombia) working at three private and public companies were recruited for the study. Two of the authors separately verified the quality of the data collected from standardized questionnaires such as the IPAQ, the sociodemographic survey, and the health history survey. Blood samples were drawn shortly after the interview, and after informed consent and approval by the ethics committee in humans had been given. Participants with a medical or clinical diagnosis of major systemic disease (including malignant conditions), diabetes, arterial hypertension, hypothyroidism or hyperthyroidism, body mass index (BMI) of 35.0 kg/m^2 or higher, a history of drug or alcohol abuse, use of multivitamin preparations, use of statins, and current inflammatory (trauma, contusion) or infectious conditions were excluded from the study.

Measurement of cardiovascular risk factors and metabolic syndrome risk factors

Assessments were made of cardiovascular risk factors reported in the National Cholesterol Education Program (NCEP) in the United States[14], hs-CRP and ferritin levels, and insulin sensitivity calculated by the Homeostatic Model Assessment-Insulin Resistance (HOMA-IR) index (using the formula: [basal insulin in mIU/L x basal blood glucose in mmol/L)/22.5]) as new markers associated with MS and cardiovascular disease[3,4]. The IDF criteria and definition[15], used as cut-off points in the Colombian population[16], were applied to MS. For this purpose, the presence of MS components had to be assessed. Such components included abdominal obesity (waist circumference ≥ 88 cm), TG (≥ 150 mg/dL), low HDL cholesterol (HDL-C) levels (< 40 mg/dL in males), systolic blood pressure ≥ 130 mmHg, diastolic blood pressure ≥ 85 mmHg, and fasting blood glucose ≥ 100 mg/dL. MS was defined as the presence of abdominal obesity plus at least two other components.

Self-reported measurement of physical activity level

The short version of the IPAQ recommended by the World Health Organization (www.ipaq.ki.se/questionnaires/ColombiaIQshtel.pdf) was self-administered by the participants as a valid measurement for the estimation of physical activity by a trained interviewer. This version consists of seven questions inquiring into the frequency, duration, and intensity of participation in physical activities such as walking or running in the week immediately prior to participation in the study and into different aspects of daily living. Metabolic equivalents (METs) were calculated in order to classify subjects into two groups:

1) *high physical activity level:* participation on at least 3 days in vigorous physical activity and at least 1,500 MET-min/week or more days of any combination of physical activity and at least 3,000 MET-min/week.
2) *low physical activity level* (less than 3 days of vigorous activity and less than 20 min/day and/or walking less than 20 min daily or a calorie expenditure lower than 600 MET-min/week).

Anthropometric measurement and body composition

A physical examination including anthropometric measurements following the Lopez et al protocol[17] was used to record height using Kramer® equipment and body weight using a Tanita® scale. Waist circumference was measured between the lowest rib and the iliac crest using a measuring tape, with the participant standing and in light clothing. Body composition was determined by a bioimpedance analysis using the Bodystat® device (Quadscan 4000, United Kingdom) to indirectly calculate body fat percentage from total fat mass (kg) and body weight.

Clinical measurement

Blood pressure was measured with a digital sphygmomanometer (OMRON®) in the right arm at two separate times, 5 min apart, with the participants sitting in a comfortable position and after a 10-min rest. Participants also completed a survey of their personal and family health history.

Biochemical measurements

Ten milliliters of blood were drawn into Vacutainer tubes with no additive by puncture into an antecubital vein. Blood samples were transported to the laboratory in iceboxes at between 4 and 8 °C, and were centrifuged at 3,000 rpm within one hour to obtain serum until processing. Biochemical markers were measured using the following techniques: hs-CRP and ferritin by immunoturbidimetric methods in an automated A-15 spectrophotometer (Biosystems, Spain), glucose, total cholesterol, TG, and HDL-C by a direct colorimetric method in an automated spectrophotometer by solubilization with detergent (Biosystems, Spain)[18]. Arterial index was calculated using the formula: total cholesterol/HDL-C. VLDL and LDL cholesterol levels were calculated using the Friedewald et al equations[19]: VLDL-C = TG/5 and LDL-C = total cholesterol — HDL-C — VLDL-C (for subjects with TG < 400 mg/dL). Insulin levels were measured by a chemiluminescence assay (IMMULITE 1000 kit, San Jose, CA)[20].

Data analysis

An exploratory analysis was first performed to determine the frequency and distribution of each of the variables tested. Pearson and Spearman correlation coefficients were used to estimate the relationship between variables of the IPAQ and cardiovascular and MS risk markers depending on variable distribution. The differences between the means obtained in the two IPAQ categories (low and high physical activity level) were assessed using a Student's t test for all variables. Variables not normally distributed were log-transformed for normalization. When variable normalization was not possible, a non-parametric Mann-Whitney U test was used to estimate differences by IPAQ categories. The association between physical activity and MS criteria was estimated using a Chi-square test, and odds ratios were calculated for each category. A value of $p < 0.05$ was considered significant, and all analyses were performed using SPSS software (Statistical Program Version 13, Chicago, IL).

Table 1 Clinical, anthropometric, and biochemical variables related to cardiovascular risk and metabolic syndrome in healthy males

Variables[a]	(n = 61)
Age (years)	47.1 ± 6.9
Clinical	
Systolic BP (mmHg)	123 ± 14
Diastolic BP (mmHg)	76 ± 9
Anthropometry and body composition	
Waist circumference (cm)	86.8 ± 9.7
BMI (kg/m^2)	26.7 ± 3.1
Body fat percentage	25.8 ± 6.0
Visceral fat percentage	12.3 ± 9.8
Biochemical	
Glucose (mg/(dL)	90.5 ± 9.1
Triglycerides (mg/(dL)	210 ± 119
Cholesterol (mg/(dL)	202 ± 200
HDL-C (mg/dL)	42.8 ± 9.2
LDL-C (mg/dL)	119.5 ± 28.5
Arterial index	4.8 ± 1.0
hs-CRP (mg/L)	2.0 ± 1.9
Ferritin (µg/L)	246 ± 183
Insulin (µm/mL)	1.05 ± 2.4
HOMA-IR	2.9 ± 1.6
Metabolic syndrome n (%)	17 (28)

BMI: body mass index; BP: blood pressure; HDL-C: HDL cholesterol; HOMA-IR: insulin sensitivity index; hs-CRP: high-sensitivity C-reactive protein; LDL-C: LDL cholesterol.
[a]Mean and standard deviation.

Table 2 Number and proportion of males by IPAQ classification

IPAQ classification	Number (%)
Low physical activity level	
Sedentary	4 (6.6)
Insufficiently active	24 (39.3)
High physical activity level	
Moderately active	26 (42.6)
Very active	7 (11.5)

Results

Description of body composition, anthropometry, and biochemical and clinical markers of the study population

The mean age of the study population was 47.1 ± 6.9 years. Mean systolic and diastolic blood pressure values were 123 ± 14 mmHg and 76 ± 9 mmHg respectively. Mean anthropometric measurements included a waist circumference of 86.8 ± 9.7 cm, BMI of 26.7 ± 3.1 kg/m^2, body fat percentage of 25.8 ± 6.0, and visceral fat percentage of 12.3 ± 9.8. Seventeen participants (28%) had MS. Table 1 shows the mean values of the biochemical parameters.

Self-reported measurement of physical activity level

Table 2 classifies participants by self-reported physical activity level. The lowest proportion of participants was found in the sedentary lifestyle category, while most were in the "moderately active" category. No differences were found between the low and high physical activity categories (Table 3), or between total physical activity (MET x week) and clinical, anthropometric, and biochemical variables (Table 4).

Low physical activity level as a low risk factor for metabolic syndrome and its criteria

In this study, subjects with low physical activity levels had a 1.1-fold higher risk of experiencing MS, but the 95% CI for this weak association was not significant. Similarly, no significant associations were found between a low physical activity level and components associated with MS (Table 5).

Discussion

The purpose of this study was to assess the relationship of physical activity level to cardiovascular risk factors and MS in 61 apparently healthy males. Unexpectedly, our study showed no significant differences between the study groups (low and high physical activity) and no significant correlation between total physical activity (MET x week) and the clinical, anthropometric, or biochemical variables studied. This study used the short version of the IPAQ, a measurement tool supported by the World Health Organization for estimating the level of physical activity in the population aged 15-69 years whose psychometric properties, such as validity and reproducibility, make it appropriate for prevalence studies based on populations similar to the one studied[21,22]. While the short version of the IPAQ has been widely tested and is used in many international studies[21,22], this study is the first one reported in Santiago de Cali where physical activity levels were measured using such a version. Today, the IPAQ is widely recognized as one of the most objective ways of measuring individual physical fitness[21,22], and it has been utilized both as a determinant of health status and as a way of measuring the risk of suffering non-transmissible chronic diseases, mainly coronary disease[23]. There are however different factors that may modify this indicator. Age has been postulated as a factor associated with decreased physical activity which is positively attenuated in people accustomed to the routine performance of physical exercise[24]. An epidemiological study supports this

Table 3 Mean values of clinical, anthropometric, and biochemical variables by level of physical activity

Variables	Physical activity level		p value
	Low (n = 28)	High (n = 33)	
Clinical			
Systolic BP (mmHg)	122.6 ± 12.5	122.4 ± 15.6	0.926
Diastolic BP (mmHg)	75.1 ± 9.8	74.9 ± 8.6	0.632
Anthropometric			
Waist circumference (cm)	86.4 ± 8.2	87.0 ± 10.8	0.992
BMI (kg/m^2)	26.6 ± 2.4	26.9 ± 3.6	0.938
Body fat percentage	26.7 ± 5.9	25.0 ± 6.0	0.138
Visceral body fat[a]	13.7 ± 14.0	11.06 ± 3.7	0.705
Biochemical			
Glucose (mg/(dL)	90.2 ± 10.2	90.8 ± 8.3	0.978
Triglycerides (mg/(dL)	201.8 ± 99.3	207.3 ± 134.6	0.776
Cholesterol (mg/(dL)	201.4 ± 30.9	202.6 ± 33.7	0.851
HDL-C (mg/dL)	43.6 ± 8.9	42.1 ± 9.6	0.993
LDL-C (mg/dL)	119.1 ± 28.6	119.8 ± 29.0	0.819
Arterial index[a]	4.7 ± 1.0	4.9 ± 1.0	0.909
Ferritin (μg/L)[b]	262 ± 188	232 ± 180	0.174
hs-CRP (mg/L)[a]	2.3 ± 2.5	1.7 ± 0.9	0.455
Insulin (mIU/mL)	13.4 ± 7.4	12.5 ± 6.3	0.576
HOMA-IR	3.0 ± 1.7	2.8 ± 1.5	0.542

BMI: body mass index; BP: blood pressure; HDL-C: HDL cholesterol; HOMA-IR: insulin sensitivity index; hs-CRP: high-sensitivity C-reactive protein LDL-C: LDL cholesterol.

[a]Range difference by the Mann-Whitney U test.

[b]Means difference using log-transformed values.

Table 4 Total physical activity (MET x week) and its relationship to clinical, anthropometric, and biochemical variables

Variables[a]	r value	p value
Clinical		
Systolic BP (mmHg)	0.047	0.720
Diastolic BP (mmHg)	0.062	0.637
Anthropometry and body composition		
Waist circumference (cm)	-0.092	0.490
BMI (kg/m^2)	-0.042	0.751
Body fat percentage	0.041	0.757
Visceral fat percentage	0.057	0.667
Biochemical		
Glucose (mg/(dL)	0.080	0.540
Triglycerides (mg/(dL)	-0.013	0.921
HDL-C (mg/dL)	-0.038	0.771
LDL-C (mg/dL)	-0.032	0.813
Cholesterol (mg/(dL)	0.037	0.779
hs-CRP (mg/dL)	-0.102	0.440
Ferritin (μg/dL)	-0.037	0.775
Arterial index	-0.194	0.134
Insulin	-0.004	0.973
HOMA-IR	-0.011	0.935

BMI: body mass index; BP: blood pressure; HDL-C: HDL cholesterol; HOMA-IR: insulin sensitivity index; hs-CRP: high-sensitivity C-reactive protein; LDL-C: LDL cholesterol.

[a]Mean and standard deviation.

hypothesis. Thus, Heath et al[25] showed in the 1980s that physical fitness, as estimated by the level of physical activity performed, decreases 9% by decade in sedentary males.

The high prevalence of subjects with a low physical activity level in our study, 45%, should be noted. This is virtually double the percentage recently reported both by Rodrigues et al[26] and Martins et al[27]. The differences found between these studies, using the same measurement criteria and physical activity levels, are probably related to how the IPAQ was administered (personal interview) and some sociodemographic conditions such as age, educational level, and socioeconomic level.

The reasons for the high prevalence of low physical activity in the evaluated participants were not identified. Certain factors that may have contributed to the high proportion of sedentary activities are related to the time available for physical activity, and include long working hours and a limited incentive to maintain an active lifestyle inside and outside the workplace. These reasons were also reported by Marcondelli et al[28] in a population similar to that of our study in which 66.7% of the subjects said that they did not have the time.

The 28% prevalence of MS shown in our study is similar to that reported by other authors in neighbouring countries[1,26-29]. From the epidemiological viewpoint, MS is responsible for a 1.5-fold increase in the overall mortality risk and a 2.5-fold increase in cardiovascular disease[22-24]. There are, however, few studies which support the association between MS and cardiovascular morbidity and

Table 5 Risk indices (odds ratio) of low physical activity for metabolic syndrome and its criteria in males

Presence	Low physical activity	
	Odds ratio	95% CI
Metabolic syndrome	1.1	0.3-2.4
Systolic blood pressure ≥ 130 or diastolic BP ≥ 85 mmHg	1.1	0.4-3.2
Triglycerides ≥ 150 mg/dL	1.3	0.4-3.9
HDL-C < 40 mg/dL	0.8	0.3-2.1
Waist circumference ≥ 88 cm	1.0	0.3-2.6

HDL-C: HDL cholesterol; 95% CI: 95% confidence interval.

mortality in the Colombian population. Some studies reported MS to be associated with a higher BMI and an increased risk of type 2 diabetes mellitus[22-24]. Other studies showed MS to be associated with an increased activity of cell adhesion molecules and dyslipidemia and increased C-reactive protein levels[3,4]. Other authors associated higher cardiovascular event rates in patients with MS with higher levels of C-reactive protein[2-4]. These correlations were not found in our study.

Most studies assessing the relationship between self-reported physical activity levels and anthropometric variables have found significant reverse associations[23,26-28]. BMI was the most commonly assessed variable, followed by central adiposity markers. However, in agreement with our study, Rodrigues et al[26] and Martins et al[27] found no relationship between BMI and the internal categories of the IPAQ[27,28]. No statistically significant linear correlation was found between the IPAQ and anthropometric and biochemical variables. However, population studies using this type of survey which assess not only physical activity, but also the potential error margin and bias of the answers to each IPAQ question are required. As regards the non-significant association with the presence of MS and its criteria, and taking into account the self-reported levels of physical activity, our results agree with those reported by Dalacorte et al and Delavar et al in Brazil and Iran respectively[29,30].

Some limitations of this study should be taken into account. One limitation was that results were not adjusted for potential confounders such as smoking, alcohol consumption, or socioeconomic status. Different studies have shown blood pressure to be strongly associated with body weight, irrespective of smoking and socioeconomic income[22-24]. It should also be noted that both the measurements and the quality of the answers to the IPAQ questionnaire may be deficient (through either overestimating or underestimating levels of physical activity) when self-reporting procedures are used because participants may avoid answering questions, something which rarely occurs in personal interviews. Finally, a small sample was used.

To conclude, the results of this study showed no significant differences between the study groups (low and high physical activity) and no significant correlation between total physical activity (MET x week) and the clinical, anthropometric, or biochemical variables studied.

Conflict of interest

The authors state that they have no conflict of interest.

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References

1. Triviño LP, Dosman V, Uribe YL, Agredo RA, Jerez AM, Ramírez-Vélez R. Estudio del estilo de vida y su relación con factores de riesgo cardiovascular en adultos de mediana edad. Acta Med Colomb. 2009;34:158-63.
2. Reaven GM Banting lecture 1988. Role of insulin resistance in human disease. Diabetes. 1988;37:1595-607.
3. Freeman DJ, Norrie J, Caslake MJ, Gaw A, Ford I, Lowe GD, et al. C-reactive protein is an independent predictor of risk for the development of diabetes in the West of Scotland Coronary Prevention Study. Diabetes. 2002;51:1596-600.
4. Fernández-Real JM, Ricart-Engel W, Arroyo E, Balançá R, Casamitjana-Abella R, Cabrero D, et al. Serum ferritin as a component of the insulin resistance syndrome. Diabetes Care. 1998;21:62-8.
5. Park YW, Zhu S, Palaniappan L, Heshka S, Carnethon MR, Heymsfield SB. The metabolic syndrome: prevalence and associated risk factor findings in the US population from the Third National Health and Nutrition Examination Survey, 1988-1994. Arch Intern Med. 2003;163:427-36.
6. Churilla JR, Fitzhugh EC. Relationship between leisure-time physical activity and metabolic syndrome using varying definitions: 1999-2004 NHANES Diab Vasc Dis Res. 2009;6:100-9.
7. Ford ES, Giles WH, Dietz WH. Prevalence of metabolic syndrome among US adults: findings from the Third National Health and Nutrition Examination Survey. JAMA. 2002;287:356-9.
8. Wildman RP, Muntner P, Reynolds K, McGinn AP, Rajpathak S, Wylie-Rosett J, et al. The obese without cardiometabolic risk factor clustering and the normal weight with cardiometabolic risk factor clustering: prevalence and correlates of 2 phenotypes among the US population (NHANES 1999-2004). Arch Intern Med. 2008;168:1617-24.
9. Alberti KG, Zimmet P, Shaw J, IDF Epidemiology Task Force Consensus Group. The metabolic syndrome-a new worldwide definition. Lancet. 2005;366:1059-62.

10. Esteghamati A, Khalilzadeh O, Rashidi A, Meysamie A, Haghazali M, Abbasi M, et al. Association between physical activity and metabolic syndrome in Iranian adults: national surveillance of risk factors of noncommunicable diseases (SuRFNCD-2007). Metabolism. 2009;58:1347-55.
11. Cameron AJ, Shaw JE, Zimmet PZ. The metabolic syndrome: prevalence in worldwide populations. Endocrinol Metab Clin North Am. 2004;33:351-75.
12. Hallal PC, Gomez LF, Parra DC, Lobelo F, Mosquera J, Florindo AA, et al. Lessons learned after 10years of IPAQ use in Brazil and Colombia. J Phys Act Health. 2010;7(Suppl 2):S259-64.
13. Parra DC, McKenzie TL, Ribeiro IC, Ferreira Hino AA, Dreisinger M, Coniglio K, et al. Assessing physical activity in public parks in Brazil using systematic observation. Am J Public Health. 2010;100:1420-6.
14. Executive Summary of the Third Report of National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). JAMA 2001;285:2486–97.
15. International Diabetes Federation, Prevalence [web site]. Bruselas: International Diabetes Federation; 2005 [cited 2008 December 11]. Available from: http://www.eatlas.idf.org/Prevalence/index.cfm
16. Perez M, Casas JP, Cubillos-Garzón LA, Serrano NC, Silva F, Morillo CA, et al. Using waist circumference as a screening tool to identify Colombian subjects at cardiovascular risk. Eur J Cardiovasc Prev Rehabil. 2003;10:328-35.
17. López CA, Ramírez-Vélez R, Gallardo CEG, Marmolejo LC Características morfofuncionales de individuos físicamente activos. Iatreia. 2008;21:121-8.
18. Kishi K, Ochiai K, Ohta Y Highly sensitive cholesterol assay with enzymatic cycling applied to measurement of remnant lipoprotein-cholesterol in serum. Clin Chem. 2002;48:737-41.
19. Friedewald WT, Levy RI, Fredrickson DS Estimation of the concentration of LDL in plasma, without use of the preparative ultracentrifuge. Clin Chem. 1972;18:499-502.
20. Grassi J, Pradelles P. Compounds labelled by the acetylcholinesterase of Electrophorus Electricus. Its preparation process and its use as a tracer or marquer in enzymo-immunological determinations. United States patent, No. 1,047,330. September 10, 1991.
21. Sarmiento OL, Schmid TL, Parra DC, Díaz-del-Castillo A, Gómez LF, Pratt M, et al. Quality of life, physical activity, and built environment characteristics among colombian adults. J Phys Act Health. 2010;7(Suppl 2):S181-95.
22. Lobelo F, Pate R, Parra D, Duperly J, Pratt M. Burden of mortality associated to physical inactivity in Bogota, Colombia. Rev Salud Publica (Bogota). 2006;8(Suppl 2):28-41.
23. Blair SN, Kohl HW, Paffenbarger RS, Clark DG, Cooper KH, Gibbons LW. Physical fitness and all-cause mortality: a prospective study of healthy men and women. JAMA. 1989;22:2395-401.
24. Lee IM, Hsieh CC, Paffenbarger RS. Exercise intensity and longevity in men. The Harvard Alumni Health Study. JAMA. 1995;273:1179-784.
25. Heath GW, Hagberg JM, Ehsani AA, Holloszy JO. A physiological comparison of young and older endurance athletes. J Appl Physiol. 1981;51:634-40.
26. Rodrigues ESR, Cheik NC, Mayer AF. Nível de atividade física e tabagismo em universitários. Rev Saúde Pública. 2008;42: 672-8.
27. Martins MD, Ricarte IF, Rocha CH, Maia RB, Silva VB, Veras AB, et al. Blood pressure, excess weight and level of physical activity in students of a public university. Arq Bras Cardiol. 2010;95:192-9.
28. Marcondelli P, Costa THM, Schmitz BAS. Nível de atividade física e hábitos alimentares de universitários do 3° ao 5° semestres da área da saúde. Rev Nutr. 2008;21:39-47.
29. Dalacorte RR, Reichert CL, Vieira JL. Metabolic syndrome and physical activity in southern Brazilian community-dwelling elders: a population-based, cross-sectional study. BMC Public Health. 2009;21:9-25.
30. Delavar MA, Sann LM, Hassan ST, Linn KG, Hannachi P. Physical Activity and the Metabolic Syndrome in Middle Aged Women, Babol, Mazandaran province. Iran. EJSR 2008;22:411-21.