



Original Article

## The relationship between physical activity levels and metabolic syndrome in male white-collar workers

KWANG-JUN KO, PhD<sup>1)</sup>, EON-HO KIM PhD<sup>2)</sup>, UN-HYO BAEK, PhD<sup>3)</sup>, ZHAO GANG PhD<sup>4)</sup>, SEOL-JUNG KANG, PhD<sup>5)</sup>\*

<sup>1)</sup> Department of Sports Medicine, National Fitness Center, Republic of Korea

<sup>2)</sup> Department of Sports Science, Korea Institute of Sport Science, Republic of Korea

<sup>3)</sup> Department of Sports Science, Kyungnam University, Republic of Korea

<sup>4)</sup> Department of Physical Education, Shenzhen University, China

<sup>5)</sup> Department of Physical Education, Changwon National University: 20 Changwondaehak-ro, Uichang-gu, Changwon-si, Gyeongsangnam-do, Republic of Korea

**Abstract.** [Purpose] Physical activity is important for preventing and managing metabolic syndrome. White-collar workers can be inherently predisposed to chronic diseases, as their jobs are primarily sedentary. The purpose of this study was to examine the relationship between physical activity and metabolic syndrome in male white-collar workers. [Subjects and Methods] Physical activity and metabolic syndrome factors were measured in 331 male public office workers. Physical activity was classified as high (N=101), moderate (N=115), or low (N=111) using the International Physical Activity Questionnaire. To diagnose metabolic syndrome, the U.S. National Cholesterol Education Program's standard was used. [Results] Waist circumference and triglyceride levels, factors of metabolic syndrome, were significantly higher in the low physical activity group than in the moderate or high activity group. High-density lipoprotein cholesterol was significantly lower in the low physical activity group than in the moderate or high activity group. Waist circumference and fasting glucose were negatively correlated with physical activity level, and HDL cholesterol showed a positive correlation with waist circumference. The odds ratios for metabolic syndrome were 2.03 times higher (95% confidence interval, 1.01–4.09) in the low physical activity group than in the high physical activity group. [Conclusion] Low physical activity was a risk factor for metabolic syndrome in white-collar workers. Therefore, increasing physical activity in daily life may prevent metabolic syndrome in white-collar workers.

**Key words:** White-collar work, Metabolic syndrome, Physical activity

(This article was submitted May 20, 2016, and was accepted Jul. 19, 2016)

### INTRODUCTION

The term “metabolic syndrome” refers to the simultaneous onset and progression of factors known to trigger atherosclerosis, such as obesity, dyslipidemia, hypertension, impaired fasting glucose, and impaired glucose tolerance<sup>1, 2)</sup>. Numerous studies have revealed the clinical significance of metabolic syndrome. For example, it has been shown that the risks of cardiac disease and type 2 diabetes and their mortality rates increase when metabolic syndrome is present<sup>3–5)</sup>.

Physical inactivity and sedentary behavior as daily habits are considered major causes of metabolic syndrome<sup>6)</sup>, and it has been reported that the lack of physical activity itself can be a risk factor for early death from atherosclerotic cardiovascular disease<sup>7, 8)</sup>. Therefore, increasing physical activity in daily life is considered important for preventing metabolic

\*Corresponding author. Seol-Jung Kang (E-mail: sjkang803@hanmail.net)

©2016 The Society of Physical Therapy Science. Published by IPEC Inc.

This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (by-nc-nd) License <<http://creativecommons.org/licenses/by-nc-nd/4.0/>>.

syndrome<sup>9, 10</sup>). Studies on physical activity and metabolic syndrome reported that the prevalence of metabolic syndrome was lower in groups with high levels of physical activity than in inactive groups, showing an inverse correlation<sup>11, 12</sup>).

Meanwhile, physical activity level is also influenced by sociodemographic characteristics<sup>13</sup>). According to a study comparing occupation and physical activity, physical activity level was low among office workers with primarily sedentary tasks and little physical activity at work<sup>14, 15</sup>). Furthermore, office workers were reported to have inactive leisure activities after work in addition to sedentary behaviors in the workplace<sup>16, 17</sup>). Bauman et al.<sup>18</sup>) analyzed the sedentary time at work and at home in 20 countries using the International Physical Activity Questionnaire (IPAQ) and showed that the probability of sitting down for more than 9 hours per day was more than three times greater with low physical activity than it was with high physical activity. The association of physical inactivity at work and in daily life with the prevalence of metabolic syndrome has been shown in various studies. Moreover, a study by Méndez-Hernández et al.<sup>19</sup>) showed that the risk of metabolic syndrome decreased by 0.75-fold in a group with more than 3 hours of physical activity at work compared with those in a group that did not. Choi et al.<sup>20</sup>) also reported that those with sedentary tasks and low physical activity levels among 1,001 U.S. workers had a higher risk of abdominal obesity, which is the essential identifying factor of metabolic syndrome. In addition, a study by Kim et al.<sup>21</sup>), which analyzed the risk of metabolic syndrome for each occupational group in South Korea, revealed that the relative risk for metabolic syndrome was 1.25-fold higher among office workers than it was among non-office workers, and that their physical activity level was low. In other words, the risk of metabolic syndrome can be associated with physical activity levels according to a person's occupation.

However, although sociodemographic characteristics, such as occupation type of task, and work environment, affect cardiovascular disease and diabetes are important factors in metabolic syndrome<sup>22-24</sup>), studies elucidating the effect of preventing metabolic syndrome by taking into account the physical activity level of white-collar workers with primarily sedentary tasks are lacking. Therefore, the present study examined the relationship between physical activity level and metabolic syndrome by considering the daily physical activity level of white-collar workers.

## SUBJECTS AND METHODS

General characteristics, physical activity levels, and metabolic syndrome factors were assessed in 385 male white-collar workers who participated in the 2013 Seoul Metabolic Syndrome Management Campaign (May, 2013). After excluding those who did not participate in the survey for measuring physical activity or blood testing, 331 male white-collar workers were selected as study subjects. The study was approved by the ethics and research committee for research involving human beings of the institution in which the study was performed. All subjects gave written informed consent before participating in the study.

Height and weight were measured using an electronic scale (inBody4.0, Biospace, Seoul, South Korea). For waist circumference, the midpoint of the subcostal region and the upper iliac crest on both sides was measured to the nearest 0.1 cm in the standing position using a measuring tape.

Blood pressure was measured once in the right arm using an electronic hematomometer (FT-700R, Jawon Medical, Gyeongsan, South Korea) in a sitting position after 10 minutes of rest. When the reading was abnormal, blood pressure was remeasured after another 10 minutes of rest.

For blood testing, venous blood was collected on an empty stomach after the patient had fasted for more than 10 hours, after which fasting glucose, high-density lipoprotein (HDL) cholesterol and triglycerides were measured.

Physical activity levels of the study subjects were measured by a long-form, self-administered version of the IPAQ questionnaire<sup>25</sup>). The level of physical activity was calculated from the data obtained in the present study based on the score conversion system of the IPAQ. The activity level measured with the IPAQ was divided into low, moderate, and high physical activity, as follows:

1. Low physical activity: no activity was reported or some activity was reported but not enough to meet categories 2 or 3.
2. Moderate physical activity: any of the following 3 criteria.
  - a. 3 or more days of vigorous-intensity activity of at least 20 minutes per day.
  - b. 5 or more days of moderate-intensity activity and/or walking for at least 30 minutes per day.
  - c. 5 or more days of any combination of walking, moderate-intensity, or vigorous-intensity activities achieving a minimum of at least 600 MET-min/week.
3. High physical activity: either of the following 2 criteria.
  - a. Vigorous-intensity activity of at least 3 days per week and accumulation of at least 1,500 MET-min/week.
  - b. 7 or more days of any combination of walking or moderate- or vigorous-intensity activity accumulation of at least 3,000 MET-min/week.

Metabolic syndrome diagnostic criteria consisted of the 5 components suggested by National Cholesterol Education Program Treatment Panel III (NCEP-ATP)<sup>26</sup>). The waist circumference classifications for Asian populations suggested by the WHO were consulted<sup>27</sup>). Subjects were diagnosed with metabolic syndrome if three or more of the following conditions were met: HDL  $\leq$ 40 mg/dl, triglycerides  $\geq$ 150 mg/dL, SBP and DBP at rest  $\geq$ 130 or  $\leq$ 85 mmHg, fasting glucose  $\geq$ 100 mg/dl, or waist circumference  $\geq$ 90 cm.

To examine the general characteristics of the study subjects, means and standard deviations were calculated from their body

**Table 1.** General characteristics of the participants and their metabolic syndrome variables according to level of physical activity

Physical activity	Low (N=111)	Moderate (N=115)	High (N=105)
Age (years)	48.1 ± 7.3	47.8 ± 7.2	48.8 ± 6.0
Weight (kg)	169.9 ± 6.4	170.6 ± 5.6	170.2 ± 5.4
Height (cm)	71.0 ± 9.0	70.2 ± 9.4	69.9 ± 7.7
Physical activity***	1,367.6 ± 960.8 <sup>a&lt;b&lt;c</sup>	3,604.2 ± 1,579.1	7,219.9 ± 3,296.8
Smokes, n (%)	60 (54.1)	61 (53.0)	46 (43.8)
Drinks, n (%)	54 (48.8)	63 (54.8)	48 (45.7)
MS factor			
WC (cm)*	82.8 ± 7.1 <sup>a&gt;b,c</sup>	80.5 ± 7.8	80.7 ± 6.6
TG (mg/dl)*	163.1 ± 124.0 <sup>a&gt;b,c</sup>	127.2 ± 69.8	132.6 ± 113.2
HDL (mg/dl)**	49.3 ± 12.7 <sup>a&lt;b,c</sup>	53.3 ± 12.8	54.2 ± 12.5
SBP (mmHg)	134.5 ± 13.7	132.3 ± 15.7	132.4 ± 14.9
DBP (mmHg)	84.1 ± 9.0	82.4 ± 10.3	81.9 ± 10.4
FG (mg/dl)	97.1 ± 22.8	92.6 ± 12.1	91.9 ± 14.9

Data are shown as mean ± standard deviation values unless otherwise indicated.

a: low physical activity; b: moderate physical activity; c: high physical activity; DBP: diastolic blood pressure; FG: fasting glucose; HDL: high-density lipoprotein cholesterol; MS: metabolic syndrome; SBP: systolic blood pressure; TG: triglycerides; WC: waist circumference

\*p<0.05, \*\*p<0.01, \*\*\*p<0.001

**Table 2.** Association between physical activity and metabolic syndrome factors

	WC	TG	HDL	SBP	DBP	FG
Physical activity	-0.176***	-0.050	0.113*	0.000	-0.065	-0.135*

DBP: diastolic blood pressure; FG: fasting glucose; HDL: high-density lipoprotein cholesterol; SBP: systolic blood pressure; TG: triglycerides; WC: waist circumference

\*p<0.05, \*\*\*p<0.001

measurements, and metabolic syndrome factors (continuous variables) and engaging in drinking and smoking (categorical variables) were expressed as frequencies and percentages. To observe the differences between metabolic syndrome-related factors according to physical activity level, one-way analysis of variance was performed. To verify the associations between metabolic syndrome variables and physical activity level, odds ratios was calculated using logistic regression analysis. The level of statistical significance ( $\alpha$ ) was set at 0.05.

## RESULTS

The comparison of groups according to physical activity level did not show differences in age, weight, and height among groups. Regarding metabolic syndrome factors, waist circumference and triglycerides were significantly lower in the moderate and high physical activity groups than in the low activity group ( $p<0.05$  and  $p<0.05$ , respectively). HDL cholesterol was significantly higher in the moderate and high physical activity groups than in the low activity group ( $p<0.05$ ). Although there were differences in systolic and diastolic blood pressure and fasting glucose level between the physical activity levels, they were not significant (Table 1).

In the relationship between physical activity and metabolic syndrome factors, waist circumference and fasting glucose showed negative correlations ( $p<0.001$  and  $p<0.05$ , respectively), whereas HDL cholesterol showed a positive correlation ( $p<0.05$ ). However, triglycerides, systolic blood pressure, and diastolic blood pressure did not show significant relationships (Table 2).

The prevalence of metabolic syndrome according to the level of physical activity was 25.2% for the low physical activity group, 13% for the moderate physical group, and 14.3% for the high physical group; it was significantly lower in the moderate and high physical activity groups ( $p<0.05$ ). The prevalence of metabolic syndrome according to an HDL cholesterol level  $\leq 40$  mg/dl was 27.0% in the low physical activity group, 13.9% in the moderate physical activity group, and 9.5% in the high physical activity group ( $p<0.001$ ). Fasting glucose also showed significant differences, with the prevalences of metabolic syndrome being 29.7% in the low physical activity group, 20.0% in the moderate physical activity group, and 16.2% in the

**Table 3.** Prevalence of metabolic syndrome according to level of physical activity

Physical activity	Metabolic syndrome*	WC	TG	HDL***	BP	FG*
		≥90 cm	≥150 mg/dl	≤40 mg/dl	≥130 or ≤85 mmHg	≥100 mg/dl
Low (N=111)	28 (25.2)	21 (18.9)	36 (32.4)	30 (27.0)	78 (70.3)	33 (29.7)
Moderate (N=115)	15 (13.0)	16 (13.9)	31 (27.0)	16 (13.9)	65 (56.5)	23 (20.0)
High (N=105)	15 (14.3)	12 (11.4)	23 (21.9)	10 (9.5)	61 (58.1)	17 (16.2)
Total (N=331)	58 (17.5)	49 (14.8)	90 (27.2)	56 (16.9)	204 (61.6)	73 (22.1)

Data are shown as numbers (%). BP: blood pressure; FG: fasting glucose; HDL: high-density lipoprotein cholesterol; TG: triglycerides; WC: waist circumference

\*p<0.05, \*\*\*p<0.001

**Table 4.** Odds ratio of having metabolic syndrome according to level of physical activity

	Adjusted	
	OR	(95% CI)
High physical activity	1.00	
Moderate physical activity	0.85	(0.39–1.85)
Low physical activity	2.03	(1.01–4.09)

CI: confidence interval; OR: odds ratio

**Table 5.** Odds ratio of having metabolic syndrome variables according to level of physical activity

Physical activity	WC	TG	HDL	BP	FG
	≥90 cm	≥150 mg/dl	≤40 mg/dl	≥130 or ≤85 mmHg	≥100 mg/dl
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
High	1.00	1.00	1.00	1.00	1.00
Moderate	1.24 (0.55–2.80)	1.18 (0.62–2.24)	1.55 (0.66–3.61)	1.76 (0.99–3.13)	1.23 (0.60–2.53)
Low	1.86 (0.86–4.02)	1.73 (0.92–3.25)	3.52 (1.62–7.67)	0.89 (0.51–1.54)	2.36 (1.19–4.66)

BP: blood pressure; FG: fasting glucose; HDL: high-density lipoprotein cholesterol; OR: odds ratio; TG: triglycerides; WC: waist circumference

high physical activity group (p<0.05). However, waist circumference, triglycerides, blood pressure, and other variables did not show differences (Table 3).

The odds ratio for metabolic syndrome according to the level of physical activity was 2.03 (95% CI, 1.01–4.09) in the low physical activity group. This group had a greater risk of developing metabolic syndrome than the group with a high level of physical activity (Table 4).

With respect to metabolic syndrome factors according to the level of physical activity, the odds ratio for HDL cholesterol level ≤40 mg/dl was 3.52 (95% CI, 1.62–7.67), with the low physical activity group having an increased risk compared with the high physical activity group, and the odds ratio for fasting glucose ≥100 mg/dl increased to 2.36 (95% CI, 1.19–4.66). However, waist circumference, triglycerides, and blood pressure factors did not show significant associations (Table 5).

## DISCUSSION

The present study examined the relationship between physical activity level and metabolic syndrome in male white-collar workers by dividing the workers into low, moderate, and high physical activity groups according to IPAQ classification. The study results showed that the moderate and highly active groups showed significant differences compared with the low activity group in waist circumference, triglycerides, and HDL cholesterol, which are the risk factors for metabolic syndrome. The study also showed that the level of physical activity was associated with waist circumference, fasting glucose, and HDL cholesterol. Furthermore, the prevalence of metabolic syndrome was low for workers with moderate and high physical activities compared with those with low physical activity.

Previous studies have already proven that physical activity and exercise play a crucial role in preventing metabolic syndrome, a complex cardiovascular disease<sup>28, 29</sup>, and moderate or vigorous physical activity is recommended for health promotion and prevention of chronic disease<sup>30</sup>. However, adults generally do not engage in physical activity or exercise

of moderate intensity or higher, and a lifestyle with primarily sedentary behavior is prevalent<sup>31</sup>). A study on the prevalence of metabolic syndrome showed that the risk of metabolic syndrome decreased as the level of physical activity increased<sup>32</sup>). Moreover, decreased physical activity has been shown to be associated with metabolic syndrome factors such as obesity, hypertension, diabetes, and dyslipidemia<sup>33–35</sup>), and a group with high levels of physical activity had a lower incidence of metabolic syndrome compared with those in an inactive group, showing a negative correlation<sup>11</sup>). Similar to previous studies, the present study showed that for metabolic syndrome factors according to the level of physical activity in male white-collar workers, waist circumference and triglycerides were significantly higher in the group with low physical activity than they were in the moderate or high physical activity groups, while HDL cholesterol was significantly lower in the low physical activity group than it was in the moderate or high activity group. In addition, with respect to the association between physical activity level and metabolic syndrome, waist circumference and fasting glucose showed a negative correlation, whereas HDL cholesterol showed a positive correlation. These results indicate that although not all of the factors of metabolic syndrome showed clear differences according to the level of physical activity in public office workers, moderate and high levels of physical activity are effective in decreasing risk factors for metabolic syndrome in white-collar workers compared with low levels of physical activity. This suggests that reducing sedentary lifestyles and inactivity and increasing the level of physical activity in daily life an important for white-collar workers who are at risk of metabolic syndrome due to a sedentary work environment.

A previous investigation of 7,432 adults using the IPAQ showed that a group that exercised more than 3 times per week (20.3%) had a lower prevalence of metabolic syndrome than a the group without physical activity (36.2%)<sup>36</sup>). A prospective cohort study of 874 middle-aged men and women showed a lower prevalence of metabolic syndrome in a group with high physical activity levels<sup>12</sup>), and the odds ratio for metabolic syndrome prevalence tended to decrease as the level of physical activity increased<sup>37</sup>). In a study by Zhu et al.<sup>38</sup>) of 11,239 adults examined as part of the Third National Health and Nutrition Examination Survey (NHANES III) in the U.S., when a group without physical activity was given a value of 1, the odds ratio for the prevalence of metabolic syndrome in a group with high physical activity was 0.41 times (95% CI, 0.31–0.54) greater in males. In a study by Chung<sup>39</sup>), when a group that engaged in regular exercise more than 5 times per week was given a value of 1, the odds ratio a group without any exercise increased by 1.7 times (95% CI, 1.0–2.8). In the present study, the overall prevalence of metabolic syndrome was 17.5% in male public office workers; according to the physical activity level, the prevalence of metabolic syndrome was higher in those with low physical activity (25.2%) than in those with moderate (13.0%) or high (14.3%) activity. The odds ratio for metabolic syndrome was 2.03-fold higher in the group with low physical activity (95% CI, 1.01–4.09) compared with the high physical activity group. As the physical activity level decreased in public office workers whose work mainly involved sedentary tasks, the risk of metabolic syndrome incidence also tended to decrease. This indicates that the level of physical activity is important for decreasing the risk of metabolic syndrome.

However, because the study was a cross-sectional study on white-collar workers within a certain region, it is limited in terms of predicting the incidence of metabolic syndrome according to physical activity level. Furthermore, we did not analyze any job-related factors, such as employment history, position, and work stress, which is another limitation of the present study. Further analysis of such factors may reveal further indicators of being at risk for metabolic syndrome and other health conditions.

In conclusion, the present study showed that low physical activity is associated with a higher prevalence of metabolic syndrome in white-collar workers whose work primarily involves sedentary tasks. Therefore, this suggests that increasing the level of physical activity is important for preventing metabolic syndrome in office workers with relatively low physical activity.

## REFERENCES

- 1) Alberti KG, Zimmet PZ: Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. *Diabet Med*, 1998, 15: 539–553. [[Medline](#)] [[CrossRef](#)]
- 2) Reaven GM: Banting lecture 1988. Role of insulin resistance in human disease. *Diabetes*, 1988, 37: 1595–1607. [[Medline](#)] [[CrossRef](#)]
- 3) Gupta AK, Dahlöf B, Sever PS, et al. Anglo-Scandinavian Cardiac Outcomes Trial-Blood Pressure Lowering Arm Investigators: Metabolic syndrome, independent of its components, is a risk factor for stroke and death but not for coronary heart disease among hypertensive patients in the ASCOT-BPLA. *Diabetes Care*, 2010, 33: 1647–1651. [[Medline](#)] [[CrossRef](#)]
- 4) Meigs JB: Epidemiology of the metabolic syndrome, 2002. *Am J Manag Care*, 2002, 8: S283–S292, quiz S293–S296. [[Medline](#)]
- 5) Mottillo S, Filion KB, Genest J, et al.: The metabolic syndrome and cardiovascular risk a systematic review and meta-analysis. *J Am Coll Cardiol*, 2010, 56: 1113–1132. [[Medline](#)] [[CrossRef](#)]
- 6) Wu PY, Song XM, Jin QL, et al.: Metabolic syndrome and lifestyle in China. *J Community Nutr*, 2004, 6: 141–145.
- 7) Gustat J, Srinivasan SR, Elkasabany A, et al.: Relation of self-rated measures of physical activity to multiple risk factors of insulin resistance syndrome in young adults: the Bogalusa Heart Study. *J Clin Epidemiol*, 2002, 55: 997–1006. [[Medline](#)] [[CrossRef](#)]
- 8) Wareham NJ, Hennings SJ, Byrne CD, et al.: A quantitative analysis of the relationship between habitual energy expenditure, fitness and the metabolic cardiovascular syndrome. *Br J Nutr*, 1998, 80: 235–241. [[Medline](#)] [[CrossRef](#)]
- 9) Eckel RH, Grundy SM, Zimmet PZ: The metabolic syndrome. *Lancet*, 2005, 365: 1415–1428. [[Medline](#)] [[CrossRef](#)]
- 10) Faam B, Hosseinpah F, Amouzegar A, et al.: Leisure-time physical activity and its association with metabolic risk factors in Iranian adults: Tehran Lipid and



Glucose Study, 2005–2008. *Prev Chronic Dis*, 2013, 10: E36. [[Medline](#)] [[CrossRef](#)]

- 11) Ekelund U, Brage S, Franks PW, et al.: Physical activity energy expenditure predicts progression toward the metabolic syndrome independently of aerobic fitness in middle-aged healthy Caucasians: the Medical Research Council Ely Study. *Diabetes Care*, 2005, 28: 1195–1200. [[Medline](#)] [[CrossRef](#)]
- 12) Franks PW, Ekelund U, Brage S, et al.: Does the association of habitual physical activity with the metabolic syndrome differ by level of cardiorespiratory fitness? *Diabetes Care*, 2004, 27: 1187–1193. [[Medline](#)] [[CrossRef](#)]
- 13) Ford ES, Giles WH, Dietz WH: Prevalence of the metabolic syndrome among US adults: findings from the third National Health and Nutrition Examination Survey. *JAMA*, 2002, 287: 356–359. [[Medline](#)] [[CrossRef](#)]
- 14) Steele R, Mummery K: Occupational physical activity across occupational categories. *J Sci Med Sport*, 2003, 6: 398–407. [[Medline](#)] [[CrossRef](#)]
- 15) Lallukka T, Lahelma E, Rahkonen O, et al.: Associations of job strain and working overtime with adverse health behaviors and obesity: evidence from the Whitehall II Study, Helsinki Health Study, and the Japanese Civil Servants Study. *Soc Sci Med*, 2008, 66: 1681–1698. [[Medline](#)] [[CrossRef](#)]
- 16) Held C, Iqbal R, Lear SA, et al.: Physical activity levels, ownership of goods promoting sedentary behaviour and risk of myocardial infarction: results of the INTERHEART study. *Eur Heart J*, 2012, 33: 452–466. [[Medline](#)] [[CrossRef](#)]
- 17) Jans MP, Proper KI, Hildebrandt VH: Sedentary behavior in Dutch workers: differences between occupations and business sectors. *Am J Prev Med*, 2007, 33: 450–454. [[Medline](#)] [[CrossRef](#)]
- 18) Bauman A, Ainsworth BE, Sallis JF, et al. IPS Group: The descriptive epidemiology of sitting. A 20-country comparison using the International Physical Activity Questionnaire (IPAQ). *Am J Prev Med*, 2011, 41: 228–235. [[Medline](#)] [[CrossRef](#)]
- 19) Méndez-Hernández P, Flores Y, Siani C, et al.: Physical activity and risk of metabolic syndrome in an urban Mexican cohort. *BMC Public Health*, 2009, 9: 276. [[Medline](#)] [[CrossRef](#)]
- 20) Choi B, Schnall PL, Yang H, et al.: Sedentary work, low physical job demand, and obesity in US workers. *Am J Ind Med*, 2010, 53: 1088–1101. [[Medline](#)] [[CrossRef](#)]
- 21) Kim E, Oh SW: Gender differences in the association of occupation with metabolic syndrome in Korean adults. *Korean J Obes*, 2012, 21: 108–114. [[CrossRef](#)]
- 22) Martínez MC, Latorre MR: Risk factors for hypertension and diabetes mellitus in metallurgic and siderurgic company's workers. *Arq Bras Cardiol*, 2006, 87: 471–479. [[Medline](#)] [[CrossRef](#)]
- 23) Morikawa Y, Nakagawa H, Ishizaki M, et al.: Ten-year follow-up study on the relation between the development of non-insulin-dependent diabetes mellitus and occupation. *Am J Ind Med*, 1997, 31: 80–84. [[Medline](#)] [[CrossRef](#)]
- 24) Nagaya T, Yoshida H, Takahashi H, et al.: Incidence of type-2 diabetes mellitus in a large population of Japanese male white-collar workers. *Diabetes Res Clin Pract*, 2006, 74: 169–174. [[Medline](#)] [[CrossRef](#)]
- 25) Craig CL, Marshall AL, Sjöström M, et al.: International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc*, 2003, 35: 1381–1395. [[Medline](#)] [[CrossRef](#)]
- 26) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults: Executive summary of the third report of the 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: 2486–2497. [[Medline](#)] [[CrossRef](#)]
- 27) WHO: West Pacific Region The Asia-Pacific perspective: reading obesity and its treatment. IOTF, 2000.
- 28) Azadbakht L, Mirmiran P, Esmailzadeh A, et al.: Beneficial effects of a Dietary Approaches to Stop Hypertension eating plan on features of the metabolic syndrome. *Diabetes Care*, 2005, 28: 2823–2831. [[Medline](#)] [[CrossRef](#)]
- 29) Lakka TA, Laaksonen DE: Physical activity in prevention and treatment of the metabolic syndrome. *Appl Physiol Nutr Metab*, 2007, 32: 76–88. [[Medline](#)] [[CrossRef](#)]
- 30) U.S. Department of Health and Human Services: 2008 Physical Activity Guidelines for Americans. Hyattsville: U.S. Department of Health and Human Services, 2008.
- 31) Brockow T, Conradi E, Ebenbichler G, et al.: The role of mild systemic heat and physical activity on endothelial function in patients with increased cardiovascular risk: results from a systematic review. *Forsch Komplement Med*, 2011, 18: 24–30. [[Medline](#)] [[CrossRef](#)]
- 32) Lakka TA, Laaksonen DE, Lakka HM, et al.: Sedentary lifestyle, poor cardiorespiratory fitness, and the metabolic syndrome. *Med Sci Sports Exerc*, 2003, 35: 1279–1286. [[Medline](#)] [[CrossRef](#)]
- 33) Carroll S, Cooke CB, Butterly RJ: Metabolic clustering, physical activity and fitness in nonsmoking, middle-aged men. *Med Sci Sports Exerc*, 2000, 32: 2079–2086. [[Medline](#)] [[CrossRef](#)]
- 34) Wannamethee SG, Shaper AG, Alberti KG: Physical activity, metabolic factors, and the incidence of coronary heart disease and type 2 diabetes. *Arch Intern Med*, 2000, 160: 2108–2116. [[Medline](#)] [[CrossRef](#)]
- 35) Whaley MH, Kampert JB, Kohl HW 3rd, et al.: Physical fitness and clustering of risk factors associated with the metabolic syndrome. *Med Sci Sports Exerc*, 1999, 31: 287–293. [[Medline](#)] [[CrossRef](#)]
- 36) Churilla JR, Johnson TM, Magyari PM, et al.: Descriptive analysis of resistance exercise and metabolic syndrome. *Diabetes Metab Syndr*, 2012, 6: 42–47. [[Medline](#)] [[CrossRef](#)]
- 37) Brock K, Huang WY, Fraser DR, et al.: Low vitamin D status is associated with physical inactivity, obesity and low vitamin D intake in a large US sample of healthy middle-aged men and women. *J Steroid Biochem Mol Biol*, 2010, 121: 462–466. [[Medline](#)] [[CrossRef](#)]
- 38) Zhu S, St-Onge MP, Heshka S, et al.: Lifestyle behaviors associated with lower risk of having the metabolic syndrome. *Metabolism*, 2004, 53: 1503–1511. [[Medline](#)] [[CrossRef](#)]
- 39) Chuang SY, Chen CH, Chou P: Prevalence of metabolic syndrome in a large health check-up population in Taiwan. *J Chin Med Assoc*, 2004, 67: 611–620. [[Medline](#)]