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The Relationship Between Physical Activity and Metabolic Syndrome in People With Chronic Obstructive Pulmonary Disease

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Abstract

Background—The prevalence of metabolic syndrome has been reported to be 20% to 50% in people with chronic obstructive pulmonary disease (COPD). Because such people are sedentary and physically inactive, they are at risk of metabolic syndrome. The extent of this problem, however, is not fully understood.

Objectives—This study examined the relationship of sedentary time and physical activity to metabolic syndrome and the components of metabolic syndrome in a population-based sample of people with COPD.

Methods—This was a secondary analysis of existing cross-sectional data. Subjects with COPD (n = 223) were drawn from the National Health and Nutrition Examination Survey data set (2003–2006). Physical activity was measured by accelerometry. Waist circumference, triglyceride level, high-density lipoprotein cholesterol level, blood pressure, and fasting glucose level were used to describe metabolic syndrome. Descriptive and inferential statistics were used for analysis.

Results—Fifty-five percent of the sample had metabolic syndrome. No significant differences in sedentary time and level of physical activity were found in people with COPD and metabolic syndrome and people with COPD only. However, those with a mean activity count of greater than 240 counts per minute had a lower prevalence of metabolic syndrome. Waist circumference and glucose level were significantly associated with the time spent in sedentary, light, and moderate to vigorous physical activity.

Conclusion—Metabolic syndrome is highly prevalent in people with COPD, and greater physical activity and less sedentary time are associated with lower rates of metabolic syndrome. This suggests that interventions to decrease the risk of metabolic syndrome in people with COPD should include both reducing sedentary time and increasing the time and intensity of physical activity.

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Keywords

ActiGraph accelerometry; COPD; metabolic syndrome; physical activity; sedentary time

Metabolic syndrome represents a cluster of risk factors that increase the risk of cardiovascular disease.[1,2] It is characterized by central obesity, an elevated level of triglycerides (TGs), elevated blood pressure, a decreased level of high-density lipoprotein (HDL) cholesterol, and an increased level of glucose.[3] The prevalence of metabolic syndrome has been reported worldwide.[4] One study showed that people with metabolic syndrome were 1.32 to 1.79 times more likely to die of all causes than those without metabolic syndrome.[5] Physical activity (PA) has been reported to be significantly associated with a lower prevalence and incidence of metabolic syndrome and individual metabolic risk factors (ie, high TG levels) in the general population.[6,7] Sedentary activity and light PA (LPA) were also associated with individual metabolic risk factors, even in people who met the recommended level of moderate to vigorous PA (MVPA).[7,8]

In 2008, chronic obstructive pulmonary disease (COPD) was reported to be the third leading cause of death in the United States.[9] In 2010, it had become the fifth largest contributor to disability.[10] How people with COPD develop metabolic syndrome is still unclear, but researchers have postulated that smoking and systemic inflammation may play a role in the development of metabolic syndrome in people with COPD.[11–14] The prevalence of metabolic syndrome has been reported to be 20% to 50% in people with COPD.[11,12] However, most studies of metabolic syndrome in people with COPD have been conducted outside the United States.[11,12] Cultural differences in lifestyle could influence risk factors for metabolic syndrome. Furthermore, people with COPD are notably inactive in daily life,[15] which could increase their risk of metabolic syndrome.[16] No studies have examined the relationship between PA and metabolic syndrome in people with COPD who live in the United States.

Purpose

The purpose of this study was to examine the relationship of sedentary time and PA to metabolic syndrome and the components of metabolic syndrome in a representative sample of people with COPD in the United States.

Review of Literature

Relationship Between Physical Activity and Metabolic Syndrome in Healthy Adults and Older Adults

The link between PA and metabolic syndrome has been examined in healthy adults and older adults. Most studies relied on measures of PA derived from various questionnaires.[6,17–20] Few studies examined the relationship between objectively measured PA and metabolic syndrome.[7,21–25] Virtually all studies have reported that higher levels of PA are associated with a lower prevalence of metabolic syndrome. Studies using self-reported PA focused mainly on PA during leisure time,[18,26] which was found to be associated with metabolic syndrome more than other domains of PA.[26,27] Vigorous PA, in particular, had a stronger negative relationship with metabolic syndrome than other types of PA did.[24,28]

When the relationships between objectively measured PA and individual components of metabolic syndrome were examined, the mean activity count, recorded by accelerometer, was negatively associated with waist circumference and TG level in the general population.[7] Moderate to vigorous PA was negatively associated with waist circumference in breast cancer survivors,[29] in menopausal women,[30] in men with prostate cancer,[31] and in the general population.[7,32] In addition, MVPA was negatively associated with TG level in the general population.[7] Extremely vigorous PA lessened the probability of one having high glucose level, high blood pressure, high TG level, and low HDL level.[24] In addition, LPA was negatively associated with waist circumference in the general population[7,32] and in menopausal women.[30]

Relationship Between Sedentary Time and Metabolic Syndrome in Healthy Adults and Older Adults

A significant relationship between sedentary time or sedentary behaviors (ie, watching television) and metabolic syndrome has been reported in the literature.[33–35] Sisson et al[34] found that people who watched 4 or more hours of television a day were 54% to 94% more likely to have metabolic syndrome than were those who reported 1 hour or less. More specifically, people with metabolic syndrome had a higher percentage of sedentary time, lower average intensity of activity during sedentary time, and fewer breaks in sedentary time as measured by actigraph.[35]

When the relationship between sedentary time and the components of metabolic syndrome was examined, sedentary time was positively associated with waist circumference in the general population[7,35,36] and in menopausal women,[30] and it was positively associated with a higher TG level,[7,35,36] higher glucose level,[37] and lower HDL level[36,37] in the general population.

Relationship of Sedentary Time and Physical Activity to Metabolic Syndrome in People With Chronic Obstructive Pulmonary Disease

Few studies have examined the relationship of sedentary time and PA to metabolic syndrome in people with COPD. Low levels of PA were associated with self-reported diabetes[38] in Spanish people with COPD, but the study in question used subjective measures of PA. One study showed that the level of PA, which was measured by the SenseWear armband (BodyMedia, Inc, Pittsburgh, Pennsylvania), was significantly reduced in people with COPD and metabolic syndrome compared with people with COPD without metabolic syndrome.[16] They did not explore the detailed relationship of sedentary time and PA to metabolic syndrome.

Methods

Design

Data from the National Health and Nutrition Evaluation Survey (NHANES) were used for this secondary cross-sectional study. The National Center for Health Statistics conducted the NHANES using a cross-sectional, multistage, stratified, clustered probability design.[39] The survey's purpose was to assess the health and nutritional status of civilian, noninstitutionalized populations in the United States. To produce reliable results, the NHANES oversampled persons 60 years or older, low-income persons, African Americans, and Mexican Americans.

Sample, Settings, and Procedures

During the period 2003–2006, 21 470 people completed a NHANES interview. Of those, 427 with physician-diagnosed emphysema or chronic bronchitis, who were 55 years or older, and with a history of smoking were eligible for inclusion in this study. Individuals (n = 203) with no accelerometer data were excluded.

Survey interviews and physical examinations collected sociodemographic and clinical information. Interviews were conducted in participants' homes. Health measurements were performed in specially designed and equipped mobile centers that traveled to locations throughout the country. Transportation was provided to and from the mobile centers. Physical activity monitors were initialized and components of metabolic syndrome were obtained in the mobile centers. A technician instructed participants on the protocol for using the PA monitor, programmed the device to start at 12 AM (the day after their health examination), and placed the device on each participant's right hip. After wearing the monitor for 7 days, participants were instructed to mail them to the NHANES contractor, where the data were downloaded and outliers and unreasonable values were checked.[40] The NHANES standardized the data collection process to minimize variations between sites. The National Center for Health Statistics Ethics Review Board approved the survey protocol.

Instruments

Physical Activity—The level of PA was measured by ActiGraph (ActiGraph Model 7164 accelerometer, LLC; Ft Walton Beach, Florida). As noted above, the monitor was attached to a belt that was strapped around a person's waist. Participants were instructed to wear the device over their right hip for 7 days during waking hours and to take it off for water-related activities and at bedtime. A toll-free telephone number and informational material on the device were provided. Details of the accelerometer protocol are available.[40]

The uniaxial ActiGraph measures and records vertical acceleration as counts per minute (cpm), an indicator of intensity of movement.[35] To be considered valid, a day's data collection required at least 10 hours of wear time. We included only participants who had at least 4 valid days for our analysis. The 4-day period was chosen because it has been sufficient to describe the level of PA.[41] Zero counts for 60 minutes or more were classified as "nonwear time" and were excluded in our analysis. We used the cutpoints for PA that have been previously used and validated in the literature.[42,43] Sedentary activity, LPA, and

MVPA were defined as less than 100 cpm, 100 to 1951 cpm, and 1952 cpm or greater, respectively. The corresponding metabolic equivalent (MET) level for LPA was less than 3 METs; for MVPA, it was more than 3 METs.[43] Examples of activities with less than 3 METs include cooking, washing dishes, standing quietly, and light-intensity walking; examples of activities with more than 3 METs include moderate- or vigorous-intensity walking, gardening with heavy-power tools, running, and bicycling.[44] Mean activity intensity was also used for our analysis, which was calculated by total counts divided by total wear time. Adequate intraclass correlation coefficient (0.98) between 2 uniaxial accelerometers has been reported in the literature.[45] Concurrent validity of uniaxial accelerometer with triaxial accelerometer was 0.50 to 0.77.[46]

Metabolic Syndrome—The components of metabolic syndrome included systolic and diastolic blood pressure (SBP/DBP), fasting glucose, HDL, TG levels, and waist circumference. For each participant, SBP and DBP were measured 3 or 4 times, and mean SBP and DBP were calculated for our analysis. Fasting glucose levels and TG levels were tested during participants' morning session. Waist circumference was measured to the nearest 0.1 cm at the level of the iliac crest at the end of normal respiration. All of this clinical information was collected by examiners and technicians in NHANES who were well trained to maintain quality control in measuring the biomarkers. Further details of these measurements are available on the NHANES Web site.[47]

In 2009, in an attempt to unify criteria for the clinical diagnosis of metabolic syndrome, several major organizations met and agreed upon 5 criteria[48]: (1) central obesity (waist circumference: men, ≥102 cm; women, ≥88 cm); (2) TG levels of 150 mg/dL or greater or specific treatment for lipid abnormality; (3) HDL levels of less than 40 mg/dL in men and less than 50 mg/dL in women or specific treatment for lipid abnormality; (4) SBP 130 mm Hg or greater or DBP 85 mm Hg or greater or treatment of previously diagnosed hypertension; and (5) fasting glucose level of 100 mg/dL or greater or previously diagnosed type 2 diabetes. The NHANES participants were not asked to specify their type of diabetes. Thus, a participant was considered to have metabolic syndrome if he/she was taking any medication to control it or had been diagnosed with any type of diabetes. Three abnormal findings out of 5 are required to document the presence of metabolic syndrome.

Other Covariates—Data for age, gender, race, level of education, household income, working status, marital status, number of people in household, pack years of smoking, shortness of breath, and comorbid conditions were used to describe our sample. Participants were asked to report total household income, including salaries, social security or retirement benefits, and financial aid from relatives. Participants were also asked to respond yes or no to the question "Are you currently working?" In addition, they were asked to answer yes or no to the question "Have you had shortness of breath either when hurrying on the level or walking up a slight hill?" The number of possible comorbidities was 12: angina, arthritis, asthma, cancer, coronary heart disease, heart attack, heart failure, kidney disease, liver disease, osteoporosis, stroke, and thyroid problems. Participants were asked to answer yes or no if they had any of these conditions. We did not include diabetes and hypertension on the list of comorbidities. Cardiovascular disease comprised angina, coronary heart disease, heart attack, and heart failure. All of the information above was collected during interviews. Body mass index (BMI) was calculated by measured weight and height. All body measurements were performed by trained health technicians using standardized examination methods and calibrated equipment.[47]

Data Analysis

We used Stata version 12.0 for data analysis. All continuous variables were expressed as mean and standard deviation. Categorical variables were presented as percentage and frequency. We used the χ^2 test, linear regression, and the lincom procedure in Stata to compare study variables between COPD participants who had metabolic syndrome and those who did not.

Univariate and multivariate logistic regressions were used to examine the association of metabolic syndrome with mean activity intensity, sedentary time, and time spent in LPA and MVPA. The dependent variable in this logistic regression was metabolic syndrome. The independent variables were dichotomized for this analysis. Cutpoints for dichotomization were 1 standard deviation above the mean of different levels of PA and 1 standard deviation below the mean of sedentary time. There are no established cutpoints that are appropriate for people with COPD, and they have lower levels of PA than healthy subjects do; therefore, we chose 1 standard deviation above or below the mean of different levels of PA and sedentary time. For these multivariate logistic regressions, we first identified potential predictors of metabolic syndrome that were statistically related (ie, more than $r = 0.10$ in Pearson correlation analysis). All variables were entered together into the multivariate logistic regression model.

A multiple regression model was used to examine the relationship between sedentary time and PA and components of metabolic syndrome. For these multiple linear regressions, we also identified the potential predictors of each component of metabolic syndrome that were statistically related (ie, more than $r = 0.10$ in Pearson correlation analysis). All independent variables were then entered together into a multivariate model. A P value $< .05$ was considered statistically significant.

Results

Sample Characteristics

The final sample size of COPD subjects numbered 223. The mean age of the participants was 70.1 years (Table 1). Men comprised 51.1% of the sample. People with COPD were mainly non-Hispanic whites, and few were working. Of the 223 subjects, 124 (55.2%) had metabolic syndrome (Table 2). Of the 5 components of metabolic syndrome, high blood pressure was the most frequently reported problem. The most frequently reported component of metabolic syndrome was a high TG level, large waist circumference, and large waist circumference in people with COPD and metabolic syndrome, according to a BMI of 25 kg/m^2 or less, 25 to 30 kg/m^2, and greater than 30 kg/m^2, respectively. The most frequently reported component of metabolic syndrome was high BP, large waist circumference, and large waist circumference in people with COPD without metabolic syndrome, according to BMI (≤25, 25–30, >30 kg/m^2, respectively). No significant difference was found between COPD participants with metabolic syndrome and those without, except for level of education, working status, BMI, number of comorbidities, diabetes, hypertension, and cardiovascular disease (Table 1).

Sedentary time and all levels of PA were compared between participants with COPD who had metabolic syndrome and those who did not. No significant differences were found in sedentary time, time spent in LPA, and time spent in MVPA between the 2 groups, except mean activity intensity (Table 3).

Logistic regression showed that people with the highest mean activity intensity were less likely to have metabolic syndrome, those with a mean activity level greater than 240 cpm, which is 1 standard deviation above the mean for the total group. This relationship persisted even after adjusting for other covariates (Table 4). No significant association of sedentary time and time spent in LPA and MVPA to metabolic syndrome was found in univariate and multivariate logistic regression.

When individual components of metabolic syndrome were examined in relation to sedentary time and different levels of PA in the total sample (n = 98–224), mean activity intensity, time spent in LPA, and time spent in MVPA were negatively associated with waist circumference and glucose level (Table 5). Sedentary time was positively associated with waist circumference and glucose level, even after adjusting for covariates. Sedentary time and different levels of PA were not related to HDL levels, TG levels, and mean arterial pressure.

Discussion

In this study, people with COPD were extremely sedentary and 55% had metabolic syndrome. The mean sedentary time and time spent in different levels of PA were similar between people with and people without metabolic syndrome. However, the most active people were less likely to have metabolic syndrome. The time spent in LPA and MVPA was negatively associated with waist circumference and glucose level, whereas sedentary time was positively associated with waist circumference and glucose.

The importance of MVPA has been emphasized in the literature of COPD.[49] Few studies have examined sedentary time and LPA and their relationships to health-related outcomes in people with COPD. We found no significant difference in sedentary time and different levels of PA between participants with COPD who had metabolic syndrome and those who did not. This finding is inconsistent with the study of Watz et al,[16] in which people with COPD and metabolic syndrome showed significantly reduced levels of PA when compared with those without metabolic syndrome. The reason for these differences is not clear, but it might be related to differences in sample characteristics such as age and disease severity. The subjects in our study were older, and this may have had a dampening effect on the observed relationship, as PA declines with age. The NHANES (2003–2006) did not provide information about disease severity, so we do not know the exact disease severity of our subjects. People with more severe COPD tend to be less active and to have a lower incidence of metabolic syndrome.[16] Further study is needed to examine this issue in a well-defined COPD population.

When PA was analyzed in logistic regression, only mean activity intensity was associated with the prevalence of metabolic syndrome. People with the highest level of PA (10.8% of total sample) were less likely to have metabolic syndrome. When examined post hoc as a subgroup, these people spent a mean of 491 minutes a day in sedentary activities, 390 minutes in LPA, and 29 minutes in MVPA. As a group, they met the recommended guidelines for MVPA, but MVPA was not a significant predictor of metabolic syndrome and neither was LPA. It was the combination of MVPA and LPA that made the difference. To accomplish this level of PA in the clinical setting, one could replace sedentary activities with LPA while still emphasizing the importance of MVPA as recommended by the guidelines. This would be a reasonable strategy for people with COPD to reduce their risk of developing metabolic syndrome.

We observed significant relationships between different levels of PA and 2 components of metabolic syndrome, waist circumference and glucose level. This finding is consistent with previous research in other populations with chronic diseases.[29–31] In addition, the magnitude of the β coefficients for MVPA to waist circumference and glucose level suggests that MVPA may have a stronger influence on metabolic risk factors than LPA and sedentary time do. This finding is consistent with that of another study from the general population,[24] which reported that vigorous PA has a greater influence on metabolic syndrome. Our findings confirm the importance of encouraging more MVPA to decrease metabolic risk in COPD.

Of note, we found that LPA was also significantly associated with a reduction in metabolic risk factors, although the magnitude of the β coefficient was lower than that of MVPA. This suggests that encouraging LPA can benefit people with COPD. Recent studies have emphasized the significant effect of LPA on health-related outcomes in healthy older adults and people with other chronic diseases.[7,29] Because LPA includes activities of daily living, it can be readily promoted to reduce metabolic risk factors.

When the relationship of sedentary time to individual components of metabolic syndrome was examined, we found that waist circumference and glucose levels were significantly positively associated with sedentary time. This is consistent with the findings of Celis-Moralis et al[37] and Bankoski et al[35] from the general population and with Healy et al[7,36] from Australian adults. In our study, individuals with COPD spent most of their time in LPA and reported more than 11 hours of sedentary time, which comprises most of a day. This is concerning because recent evidence from the general population suggests that too much sedentary time has independent metabolic effects that occur regardless of the amount of MVPA.[7,36] One study showed the beneficial effect of substituting LPA for sedentary time.[42] Taken together, these findings suggest that displacing sedentary time with LPA may improve health outcomes in people with COPD. However, MVPA should still be encouraged.

This study has strengths and limitations. Its major strengths include the use of a nationally representative population and the objective measure of PA. Three limitations bear mention. First, because participants did not wear their device entire day, sedentary time may not represent true sedentary time over 24 hours. Second, activity may be understated because subjects were asked to remove their device during water-related activities. Third, because the NHANES did not test spirometry in 2003 to 2006, we could not provide disease severity.

Conclusion

We confirmed that higher activity intensity was associated with a lower prevalence of metabolic syndrome and that sedentary time and different levels of PA were associated with metabolic risk factors. Although we cannot definitively conclude that a cause-effect relationship exists between PA and metabolic syndrome or components of metabolic syndrome, the results of our study suggest that interventions to prevent metabolic risk factors in people with COPD should include the reduction of sedentary time and the promotion of PA. Future studies should prospectively examine the association between sedentary time, PA, and metabolic syndrome in people with well-defined COPD. The significant relationships found between sedentary time, PA, and metabolic syndrome further illustrate the importance of promoting PA in people with COPD.

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What's New and Important

- Higher activity intensity was significantly associated with a lower prevalence of metabolic syndrome in people with COPD.
- Sedentary time and different levels of PA were significantly associated with metabolic risk factors in people with COPD.

TABLE 1

Sample Characteristics for People With Chronic Obstructive Pulmonary Disease (N = 223)

	COPD Total (n = 223)	COPD With Metabolic Syndrome (n = 123)	COPD Without Metabolic Syndrome (n = 100)
Age, y	70.1 ± 8.7	70.6 ± 8.5	69.2 ± 8.8
Gender (male)	114 (51.1)	62 (50.4)	52 (52)
Race			
Others, including Hispanic, Mexican American, non-Hispanic Black	63 (28.3)	33 (26.8)	30 (30.0)
Non-Hispanic white	160 (71.8)	90 (73.2)	70 (70.0)
Education			
High school or less	131 (59.0)	78 (63.4)	53 (53.6)
More than high school	91 (41.0)	45 (36.6)	46 (46.5)[a]
Income			
<$25 000	109 (51.4)	62 (53.0)	47 (49.5)
$25 000–$55 000	68 (32.1)	37 (31.6)	31 (32.6)
>$55 000	35 (16.5)	18 (15.4)	17 (17.9)
Working status	32 (14.4)	13 (10.6)	19 (19.0)[a]
Marital status			
Living with someone, married	116 (52.0)	60 (48.8)	56 (56.0)
Separated, widowed, divorced	107 (49.0)	63 (51.2)	44 (44.0)
Number of people in household			
1	64 (28.7)	39 (31.7)	25 (25.0)
2–7	159 (71.3)	84 (68.3)	75 (75.0)
Pack years of smoking	59.3 ± 3.5	61.7 ± 47.7	49.6 ± 40.2
Shortness of breath on stairs/inclines	167 (74.9)	94 (76.4)	73 (73.0)
Number of comorbidities[b]	2.4 ± 1.8	2.8 ± 1.9	1.9 ± 1.5[a]
Body mass index, kg/m^2	28.7 ± 7.2	31.1 ± 7.4	25.8 ± 5.9[a]
Body mass index ≤25 kg/m^2	68 (30.4)	18 (14.6)	50 (50)
25 kg/m^2 < Body mass index ≤30 kg/m^2	78 (34.8)	49 (39.8)	29 (29)
Body mass index >30 kg/m^2	77 (34.5)	56 (45.5)	21 (21)[a]
Diabetes	46 (20.6)	35 (28.5)	11 (11.0)[a]
Hypertension	134 (60.1)	86 (69.9)	48 (48.0)[a]
Cardiovascular disease	77 (34.5)	53 (43.1)	24 (24.0)[a]

Data are provided as mean ± SD or n (%). Abbreviation: COPD, chronic obstructive pulmonary disease.

[a] $P < .05$, comparison of data between COPD with metabolic syndrome and COPD without metabolic syndrome.

[b] Number of comorbidities does not include diabetes and hypertension.

TABLE 2

Characteristics of Metabolic Syndrome in People With Chronic Obstructive Pulmonary Disease (n = 223)

	COPD
Waist circumference, cm	102.8 ± 16.8
Large waist circumference[a]	142 (66.7)
Triglycerides, mg/dL	161.7 ± 97.5
High triglycerides[a]	109 (72.2)
HDL cholesterol, mg/dL	56.5 ± 18.8
Low HDL cholesterol[a]	110 (51.0)
SBP, mm Hg	134.4 ± 21.8
DBP, mm Hg	67.0 ± 14.3
High blood pressure[a]	169 (79.0)
Fasting glucose, mg/dL	112.0 ± 32.1
High glucose[a]	85 (66.4)
Metabolic syndrome	124 (55.2)

Data are provided as mean ± SD or n (%).

Abbreviations: COPD, chronic obstructive pulmonary disease; DBP, diastolic blood pressure; HDL, high-density lipoprotein, SBP, systolic blood pressure.

[a]Criteria for metabolic syndrome: waist circumference of 102 cm or greater in men and 88 cm or greater in women; triglyceride levels 150 mg/dL or greater or specific treatment for lipid abnormality; HDL cholesterol levels of less than 40 mg/dL in men and less than 50 mg/dL in women or specific treatment for lipid abnormality; SBP 130 mm Hg or greater or DBP 85 mm Hg or greater or treatment of previously diagnosed hypertension; fasting glucose level of 100 mg/dL or greater or previously diagnosed type 2 diabetes.

TABLE 3

Comparison of the Level of Sedentary Time and Physical Activity Between People With Chronic Obstructive Pulmonary Disease and Metabolic Syndrome and People With Chronic Obstructive Pulmonary Disease Only (n = 223)

	COPD Total (n = 223)	COPD With Metabolic Syndrome (n = 123)	COPD Without Metabolic Syndrome (n = 100)
Activity intensity[a]	146.9 ± 93.5	142.1 ± 86.5	153.9 ± 101.3[b]
Sedentary time, min	675.8 ± 169.7	665.9 ± 145.2	686.8 ± 196.3
Time spent in LPA, min	249.5 ± 97.6	245.2 ± 88.0	256.5 ± 107.4
Time spent in MVPA, min	6.4 ± 11.4	5.7 ± 10.0	7.2 ± 12.9

Data are provided as mean ± SD.

Abbreviations: COPD, chronic obstructive pulmonary disease; LPA, light physical activity; MVPA, moderate to vigorous physical activity.

[a]Total counts/total wear time (minutes).

[b]$P < .05$, comparison of data between COPD with metabolic syndrome and COPD without metabolic syndrome.

TABLE 4

Odds Ratios for Association of Physical Activity With Metabolic Syndrome in People With Chronic Obstructive Pulmonary Disease From Unadjusted and Covariate Adjusted Logistic Regressions (Dependent Variable Was Metabolic Syndrome) (n = 223)

	Metabolic Syndrome (Yes vs No)	
	Unadjusted Model	**Covariate Adjusted Model[a]**
Mean activity intensity[b]		
<240 counts/min (n = 199; 89.2%)	1	1
≥240 counts/min (n = 24; 10.8%)	0.28 (0.13–0.59)[c]	0.26 (0.10–0.71)[c]
Sedentary time		
<500 min (n = 23; 10.3%)	1	1
≥500 min (n = 200; 89.7%)	2.26 (0.75–6.79)	2.46 (0.79–7.64)
Time spent in LPA		
<350 min (n=186; 83.4%)	1	1
≥350 min (n=37; 16.6%)	0.55 (0.23–1.32)	0.62 (0.23–1.69)
Time spent in MVPA		
<17 min (n = 203; 91.0%)	1	1
≥17 min (n = 20; 9.0%)	0.55 (0.27–1.16)	0.57 (0.22–1.50)

Data are presented as odds ratio (95% CI).

Abbreviations: CI, confidence interval; COPD, chronic obstructive pulmonary disease; LPA, light physical activity; MVPA, moderate to vigorous physical activity.

[a]Covariates include number of comorbidity and pack years of smoking.

[b]Total counts/total wear time (minutes).

[c]$P < .05$.

TABLE 5

Contributions (Unstandardized β) of Physical Activity Levels to Various Components of Metabolic Syndrome Based on Multiple Regression Analysis in People With Chronic Obstructive Pulmonary Disease (n = 223)

	Waist Circumference, cm	**TG, mg/dL (n = 98)**	**HDL, mg/dL**	**MAP, mm Hg**	**Glucose Level, mg/dL (n = 102)**
Overall model	$F_{4,26} = 2.86$	$F_{7,20} = 3.26$	$F_{8,22} = 10.85$	$F_{6,26} = 3.62$	$F_{5,22} = 3.93$
Mean activity intensity[a]	$\beta = -.03^b$	$\beta = .03$	$\beta = .01$	$\beta = .01$	$\beta = -.06^b$
Overall model	$F_{4,26} = 1.68$	$F_{7,20} = 3.19$	$F_{8,22} = 10.64$	$F_{6,26} = 3.21$	$F_{5,22} = 2.69$
Sedentary time, min/d[a]	$\beta = .02^b$	$\beta = -.08$	$\beta = .01$	$\beta = .01$	$\beta = .02^b$
Overall model	$F_{4,26} = 4.56$	$F_{7,20} = 3.17$	$F_{8,22} = 12.93$	$F_{6,26} = 3.64$	$F_{5,22} = 2.69$
Time spent in LPA, min/d[a]	$\beta = -.04^b$	$\beta = -.03$	$\beta = .01$	$\beta = .01$	$\beta = -.06^b$
Overall model	$F_{4,26} = 2.61$	$F_{7,20} = 3.81$	$F_{8,22} = 11.45$	$F_{6,26} = 3.48$	$F_{5,22} = 4.28$
Time spent in MVPA, min/d[a]	$\beta = -.27^b$	$\beta = 1.25$	$\beta = .15$	$\beta = .02$	$\beta = -.21^b$

All overall models were statistically significant.

Waist circumference was adjusted for age, gender, and number of comorbidities.

TG was adjusted for education, marital status, income, household number, shortness of breath, and number of comorbidities.

HDL was adjusted for age, gender, race, education, working status, number of comorbidities, and body mass index.

MAP was adjusted for age, gender, race, shortness of breath, and pack years of smoking.

Glucose level was adjusted for income, working status, shortness of breath, and body mass index.

Abbreviations: HDL, high-density lipoprotein; MAP, mean arterial pressure; LPA, light physical activity; MVPA, moderate to vigorous physical activity; TG, triglyceride.

[a]Each independent variable was analyzed separately.

[b]$P < .05$.