Original article

Low total physical activity, high total sitting time and high sitting time on a work day are correlated with low fitness in male working adults: a cross sectional study

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Abstract:

Background **:** Low fitness is an emerging factor for cardiovascular diseases. Physical activity and sitting time are arising factors that influence fitness level. There are some debates on what domain of physical activity and sitting time that have more influences on fitness level. The aims of this study were to (1) explore each domain of physical activity & sitting time and analyze their associations with low fitness in male working adults and (2) explore the differences between sitting time on a working day and a day-off.

Method **:**In this cross-sectional study, a total of 31 healthy male staffs were recruited. Participants used International Physical Activity Questionnaire (IPAQ) long version to recall their physical activity and sitting time, and their fitness level was measured by a submaximal exercise test. Data were analyzed both by univariate and multivariate techniques. Multivariable logistic regressions were employed to calculate Odds Ratio (OR) of low fitness by each domain of physical activity and sitting time.

Result **:** Data of 27 participants were considered for analysis. Total physical activity was inversely associated with low fitness [OR 0.961, 95% Confidence Interval (95% CI) 0.928 – 0.995]. Total sitting time and sitting time on a working day were positively associated with low fitness (total sitting time: OR 1.101, 95% CI 1.001-1.211; sitting time on a working day: OR 1.01, 95% CI 1.001-1.019). We also observed that sitting on a working day was significantly higher than sitting time on a day-off ($p = 0.004$).

Conclusion : The results support association of total physical activity, total sitting time and sitting time on a working day with fitness level. There were also difference between sitting time on a working day and a day-off.

Keywords: Fitness level; Cardiovascular disease; Physical activity; Sitting time

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Introduction

Cardiorespiratory fitness is an emerging concern for health and productivity among workers. This parameter, which is commonly estimated by VO2 max, measures the capacity of the cardiovascular and pulmonary systems to supply oxygen during incremental exercise. It determines the capacity to perform work and tolerance to fatigue so it has a positive correlation with the ability to work.[1] Low cardiorespiratory fitness is also a strong risk factor for cardiovascular disease[2, 3], diabetes[4-6] and all-cause mortality.[3, 7, 8]

Cardiorespiratory fitness is affected by non-modifiable factors such as genetic factors[9], age and gender[10, 11]as well as modifiable factors including physical activity[12], sitting time[13], body mass index[14], smoking[15], and medical conditions.[16] Among other modifiable factors, physical activity and sitting time are emerging concerns because of the current and prevalent change in life style. Most adults are

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becoming less physically active and sitting for prolonged periods of time.

While physical activity and sitting time are well known to affect cardiorespiratory fitness, the effects of each domain of physical activity and sitting time have been debated. Some studies showed that leisure time physical activity and sitting during leisure time have more influence on cardiorespiratory fitness.[12,13,17] Other studies claimed that workplace habits, where the employees spend most of their waking time, havestrong correlations with health outcomes.[18-21] Our study was designed to determine the relationship between each kind of domain-specific physical activity and sitting time with cardiorespiratory fitness among male workers.

Methods

Study design, procedures, and participants

From April 1 to May 31, 2017, all male officers (n=99) in the administration unit of the Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada (UGM) were invited via letter to participate in this health research. A total of 31 healthy workers were voluntarily recruited. Exclusion criteria were history of cardiovascular disease, diabetes, asthma, pulmonary obstruction and physical limitation caused by disease and accidents within the last three months. Written informed consent was obtained from all study participants prior to study entry.

Anthropometric measurement

Height was measured without shoes to the nearest centimeter, weight was measured in light clothing without shoes to nearest 0.5 kg and Body Mass Index (BMI) was calculated as ratio of body weight to height squared (kg/m^2). BMI was categorized into two groups (normoweight and overweight) based on WHO criteria. Obese were joined into the overweight group because both of them are risk factors for several diseases.

Physical activity and sitting time

Data on each domain of physical activity and sitting time were calculated from the long version of the International Physical Activity Questionnaire (IPAQ) Indonesian Version. The validity of IPAQ Indonesian version has been previously reported.[22] Physical activity was calculated as Metabolic Equivalent-Minutes (MET-minutes) per week for each domain and intensity. Data on physical activity were truncated based on the IPAQ analysis guidelines. Sedentary time was analyzed as hours per day spent sitting on a weekday and weekend day. Total sedentary time was calculated as hours per week based on the IPAQ analysis guidelines.[23]

Cardiorespiratory fitness level measurement

A submaximal exercise test using the Astrand normogram was performed on each subject using a bicycle ergometer (Monark, Sweden). Each subject started working with initial load of 300 kpm/min. Heart rate was monitored using a heart monitor (Beuer, Germany). Every minute, heart rate was recorded. The test was considered as adequate if subject's heart rate reached 130-150 beats per minute and then the test could be discontinued after 6 minutes. If the subject's heart rate did not reach 130 beats per minute, the load was increased by 300 kpm after 6 minutes. If the last two heart rate measurements gave constant pulse (the difference was not more than 5 beats per minute), we calculated the mean of those pulse rates. Conversely, if the difference between them exceeded 5 beats per minute, the working duration would be prolonged for more minutes without increasing workload until constant pulse was reached. The mean of the last two pulse rates would be used for predicting VO2 max using a normogram based on subject's weight and workload. VO2 max after correction for age was used for categorizing fitness level. Fitness categories were simplified into two categories (low fitness level and non-low fitness level) because low fitness level is considered as a significant risk factor for several diseases.

Statistical analysis

Data were analyzed using statistical analysis software. Significance was set at the 5% level. The Shapiro-Wilk test was used to test data distribution. Total physical activity and total sitting time were transformed using square root and results were back transformed. Univariate analysis was used to analyze differencesin age, BMI, physical activity and sitting time between low fitness and non-low fitness levels. Mean comparisons were performed using Student's T-test or Mann-Whitney test while categorical data were analyzed with Chi-Square test. To identify potential predictors of low fitness, multivariable logistic regression models were used. Fitness level was considered as the dependent variable. Physical activity and sitting time were assigned as the primary independent variables. Age and BMI were assigned as potential confounders. Paired sample t-tests were used to compare sitting time on a workday and during a day-off.

Ethical Clearance:

This study was submitted for publication after getting Ethical approval from the Ethics Committee of the Universitas Gadjah Mada, Yogyakarta, Indonesia,

Results

Subjects' Characteristics

Of the 31 recruited subjects, only 28 were considered for analysis because 1 subject could not finish the submaximal exercise stress test, 1 subject refused to complete the questionnaire and 1 subject was excluded based on the IPAQ analysis guidelines. Descriptive data for total 28 subjects are presented in Table 1 and Table 2. Thirty-seven percent of subjects were found to be overweight and obese. The subjects' age range was 26 to 55 years.

Physical Activity Data

Table 2 describes subjective physical activity and sitting time obtained from the long version of IPAQ Indonesian version. Seventeen (63%) of the subjects had low level of cardiorespiratory fitness. The median of subject's total physical activity was 3060 MET-minutes per week. Based on domain, the highest median of physical activity was found in the work domain which was 845 MET-minutes/week. The median of subject's total sitting time was 840 minutes/week or 2 hours/day. Based on sitting domain, sitting time on a weekday was longer than sitting time on a weekend day, with the median of 120 minutes/day and 60 minutes/day, respectively.

Table 1. Baseline characteristics of the study subjects

	Median (minimum-maximum) or N (%)
Age	45 (26-55)
BMI	
Normoweight	17 (63%)
Overweight	10 (37%)

Abbreviations: BMI = body mass index.

Table 2. Physical activity related data

	n (%) or mean (SD) or median (minimum-maximum)
Fitness Level	
• Low	17 (63%)
• Non-low	10 (37%)
Total Physical Activity [MET-min/week]	3060 (360-16407)
Physical Activity Based on Domain	
• WRPA [MET-min/week]	845 (0-11733)
• TRPA [MET-min/week]	406.5 (0-3831)
• DRPA [MET-min/week]	735 (0-4410)
• LTPA [MET-min/week]	619 (0-4632)
Physical Activity Based on Intensity	
• Walking [MET-min/week]	1020 (995.14)
• Moderate activities [MET-min/week]	1440 (200-5040)
• Vigorous activities [MET-min/week]	400 (0-10080)
Total sitting time (h/week)	840 (50-2220)
• Sitting time on a workday (h/day)	120 (10-360)
• Sitting time on a day-off (h/day)	60 (0-360)

Abbreviations: MET-min/week = metabolic equivalent-minutes/week; WRPA = work-related physical activity; TRPA = transportation-related physical activity; DPA = domestic physical activity; LTPA = leisure time physical activity.

Univariate analysis for physical activity, sitting time and fitness level

Significant univariate correlations between physical activity, sitting time, age, and BMI with fitness level are shown in Table 3. In the univariate analysis, fitness level had strong correlations with age, BMI, total physical activity, work-related physical activity, leisure-time physical activity, moderate activities, total sitting time, and sitting time on a work day. Paired-sample t-tests were performed in Table 4 to show the difference between sitting time on a work day and during a day-off.

Table 3. Participants characteristics of low fitness and non-low fitness groups

	Low Fitness Group (n=17)	Non-Low Fitness Group (n=10)	*p*-values
Age (years) [median(minimum-maximum)]	39 (26-52)	50.5 (30-55)	0.0095**
BMI			0.031*
• Normoweight [n(%)]	8 (47,1%)	9 (90%)	
• Overweight or obese [n(%)]	9 (52.9%)	1 (10%)	
Total Physical Activity [mean(sd)]	2551.83 (662.74)	6440.54 (1051.62)	0.014
Physical Activity Based on Domain			
• WRPA [MET-min/week] [median (minimum-maximum)]	613(0-9135)	2107.5 (0-11733)	0.048*
• TRPA[MET-min/week] [median(minimum-maximum)]	330 (0-1787)	925.5 (0-3831)	0.069
• DPA[MET-min/week] [median(minimum-maximum)]	540 (0-3045)	1342.5 (0-4410)	0.054
• LTPA [MET-min/week] [median(minimum-maximum)]	438 (0-4632)	1056 (99-3213)	0.018*
Physical Activity Based on Intensity			
• Walking [MET-min/week] [mean(sd)]			0.082
• Moderate activities [MET-min/ week] [median(minimum-maximum)]	840 (200-5040)	3810 (240-5040)	0.022*
• Vigorous activities [MET-min/ week] [median(minimum-maximum)]	400 (0-5760)	560 (0-10080)	0.144
Total Sitting Time (h/week) [mean(sd)]	1190.86 (115.96)	570.83 (101.30)	0.018*
• Sitting time on a work day (h/day) [median{minimum-maximum)	240 (30-360)	75 (10-300)	0.007**
• Sitting time on a day-off (h/day) [median(minimum-maximum)	60 (30-360)	60 (0-240)	0.283

Abbreviations: BMI = body mass index; MET-min/week = metabolic equivalent-minutes/week; WRPA = work-related physical activity; TRPA = transportation-related physical activity; DPA = domestic physical activity; LTPA = leisure time physical activity.

* *p*<0.05 ; ** *p*<0.01

Table 4. Sitting time on a workday vs. Sitting time on a day-off

	Mean (sd)	Difference (sd)	CI 95%	*p*-values
Sitting time on a work day (minutes)	171.11 (120.841)	67.037 (111.280)	23.016 – 111.058	0.004**
Sitting time on a day-off (minutes)	1.07 (85.587)			

Abbreviations: CI= Confidence Interval.
** $p<0.01$

Multivariate analysis for physical activity, sitting time and fitness level

Table 5 shows the multivariable logistic regression models between physical activity, sitting time and fitness level. In the models, with adjustment for age and BMI, Total physical activity showed significant negative associations with low fitness level while total sitting time and workday sitting time showed positive associations with low fitness level. There was no association of work-related, transport-related, domestic and leisure-time activities with fitness level. In addition, different intensities of physical activity also did not show any association with fitness level after adjustment for age and BMI.

Table 5. Cross-sectional associations of domain-specific physical activity and sitting time with low cardiorespiratory fitness

	Crude relative rate (95% CI)	Adjusted relative rate (95% CI)
Total physical activity	0.965 (0.936 – 0.996)	0.961 (0.928 – 0.995)*
WRPA	1 (0.999 – 1)	1 (0.999 – 1)
TRPA	0.999 (0.998 – 1)	0.999 (0.998 – 1)
DPA	0.999 (0.999 – 1)	0.999 (0.998 – 1)
LTPA	1 (0.999-1)	0.998 (0.997-1)
Walking	0.999 (0.998-1)	0.999 (0.997-1)
Moderate activities	0.999 (0.999-1)	0.999 (0.999-1)
Vigorous activities	1 (0.999-1)	1 (0.999-1)
Total sitting time	1.101 (1.009-1.201)	1.101 (1.001-1.211)*
Sitting time on a work day	1.011 (1.001-1.02)	1.01 (1.001-1.019)*

Abbreviations: BMI = body mass index; MET-min/week =metabolic equivalent-minutes/week; WRPA =work-related physical activity; TRPA =transportation-related physical activity; DPA =domestic physical activity; LTPA = leisure time physical activity; CI= Confidence Interval. Adjusted for BMI and age; * $p<0.05$

Discussion

We investigated the association of domain-specific physical activity and sitting time with fitness level in male working adults. Total physical activity, total sitting time and sitting time on a weekday were associated with cardiorespiratory fitness. Higher total physical activity was associated with a higher cardiorespiratory fitness level. Inversely, higher total sitting time and sitting time on a weekday were associated with a lower cardiorespiratory fitness level. We did not find any statistical significant association between domain-specific and intensity-specific physical activity with fitness level.

Our study showed that the prevalence of overweight and obesity among the staff in the Faculty of Medicine, Public Health and Nursing, in Universitas Gadjah Mada was 37%. This finding is consistent with a previous study in 2014 which reported that the prevalence of overweight and obesity among a sample of Universitas Gadjah Mada's staff was 39.1%.[24] The prevalence of overweight and obesity in our study was higher than the national prevalence. This trend might be due to the association of work factors with obesity. Recent studies showed that employment in administration was associated with a higher rate of obesity.[25]

From our results, the median of subject's total physical activity was 3060 MET-minutes per week. It is comparable to the amount reported in other Asian countries, such as Malaysia[26, 27] and Japan[28] (3137 MET-minutes per week and 3629 MET-minutes per week, respectively). However, it was lower than the amount of physical activity reported in Swiss[29] and Swedish[30] studies (5045 MET-minutes per week and 4536 MET-minutes per week, respectively). These findings were consistent with previous studies that found a difference in the level of self-reported physical activity between Asian and European subjects.[31] The difference might be due to the high degree of overestimating physical activity in the European subjects.[32]

There are four domains of physical activity: work-related physical activity (WRPA), transport-related physical activity (TRPA), domestic physical activity (DPA), and leisure-time physical activity (LTPA). Although the contribution of physical activity and sitting time to fitness level is well known, there is significant debate on which domain-specific physical activity affects fitness level. Some studies reported that aerobic capacity was associated with LTPA but not with WRPA. On the other hand, Hammermeister et al., Jang et al., and Hirai et al. found strong associations of occupational-related physical activity with fitness level. Nevertheless, our results found no superiority between each domain in their association with fitness level. We found that total physical activity was associated with fitness level regardless of domain, which was consistent with previous studies and existing guidelines.[33-36] ACSM/AHA recommend adults aged 18-65 need 30 minutes moderate-intensity physical activity on five days each week or 20 minutes vigorous-intensity physical activity on three days each week which can be accumulated from bouts lasting 10 or more minutes. As long as the accumulation of short bout physical activities reached the minimum amount of total activity per week, total physical activity of all domains could give benefit to fitness level. In occupational health perspectives, our results support the evidence to integrate short bouts physical activity into regular work routines, to promote active modes of transport, or to increase leisure time physical activity to improve workers' health and performance.[37-39]

Sitting time has recently gained considerable attention as a deleterious factor for health. Our findings are in agreement with previous studies showing strong association between higher sitting time and poorer cardiometabolic indicators. However, the association between different kinds of sedentary time and fitness level has not been clearly studied. Kim et al. found that sitting at work was not associated with mortality. Regarding sitting time and mortality, leisure-time sitting may have more deleterious impact than sitting at work due to coincidental unhealthy behaviors undertaken at the leisure-time, such as unhealthy snacking. On the other hand, a number of prospective studies have found that occupational sitting was related to an increased risk of diabetes mellitus,poor mental health and mortality.[40] Meta-analysis of 28 prospective cohort studies found that leisure-time spent sitting, occupational sitting time, and total sitting time are associated with higher risk of colorectal cancer.[41] In office-working male adults, our findings suggest that both total sitting time and weekday sitting time were associated with fitness level. Office workers spend most of their waking hours at workplace so it is one logical factor that affects workers' health. In addition, high amounts of sitting time in one domain cannot be compensated with occasional physical activity in other domains.[42] Active behavior in leisure time cannot counteract deleterious effects of prolonged occupational sitting time. Moreover, our study also found a statistically significant difference between duration of sitting time on a weekday and during a day off. In agreement with previous studies, our findings confirmed that administrative workers were more sedentary during weekdays than weekend days.[43-45] Subjects' sitting time on a weekday was more than 2 hours in average. As occupational sitting time gives the highest contribution to daily sitting time on weekdays[46], our results added more reasons for workplace interventions that aim to reduce occupational sitting time because sitting down for more than 2 hours a day was associated with harmful effects.[46-48]

The potential health and productivity risks of low cardiorespiratory fitness level are well studied. Low cardiorespiratory fitness levels increase the risk of various noncommunicable diseases, mortality and also negatively affect the work productivity in the general population. Our study has shown that higher total physical activity accumulated from any domain and intensity protects against low fitness levels in male working population. This finding gives a broad range of alternatives for workplace interventions to increase physical activity among workers. Higher total sitting time and occupational sitting time could be potential deleterious factors for fitness level. Based on our findings, it may be emphasized that not only supporting any kind of physical activity, but also reducing sitting time at workplace must be considered to maintain cardiorespiratory fitness among male workers.

To the best of our knowledge, no other study has investigated the cross-sectional associations of domain-specific physical activity and sitting time with cardiorespiratory fitness among male administrative workers in Indonesia. However, our study has some weakness. Since only 27 subjectswere analyzed, there is need for further investigation with a larger sample population. We also did not measure VO2max directly, but predicted it using submaximal bicycle ergometry stress testing. Spiroergometry is considered as the gold standard but is not feasible for assessing VO2max in clinical setting. Several studies confirmed the validity of submaximal exercise test with bicycle ergometry and considered that it can accurately predict fitness level in healthy adults. Our research also was a cross-sectional study, which only provided a snapshot of the correlation between physical activity, sedentary behavior and fitness level but cannot ascertain the cause-effect relationship. The subjects in our study were also voluntarily recruited which could reduce the internal validity of the study. Another limitation was physical activity and sedentary behavior were subjectively measured. Other potential confounders such as sleep behavior and socioeconomic status were not controlled in our study. To overcome these limitations in the future, longitudinal intervention studies with larger randomized samples and objectively measured physical activity and sedentary behavior are required.

Conclusions

The key finding of this cross-sectional study is that low fitness level showed a positive association with total sitting time and sitting time on a weekday. On the other hand, total physical activity showed protective association with low fitness level, regardless of domain and intensities after adjustment for age and BMI. We recommend workplace policy should encourage workers to reduce occupational sitting time and to regularly achieve the recommended total amount of physical activity.

Conflict of interest

All the authors declare no conflict of interest

Authors' Contribution:

Data gathering and idea owner of this study: Rakhmat Ari Wibowo, Widya Wasityastuti,

Study design: Rakhmat Ari Wibowo, Widya Wasityastuti, Zaenal Muttaqien Sofro

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Writing and submitting manuscript: Rakhmat Ari Wibowo, Zaenal Muttaqien Sofro

Editing and approval of final draft: Rakhmat Ari Wibowo, Widya Wasityastuti,

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