Association of objectively measured physical activity, sedentary time, and cardiorespiratory fitness with carotid artery intima-media thickness in Japanese office and factory workers

キーワード：carotid artery intima-media thickness, physical activity, sedentary time, cardiorespiratory fitness, atherosclerosis, work type

**Background and study purpose**

Nowadays, with the upcoming advent of an aging society, cardiovascular disease (CVD) has become the major non-communicable disease in the world. Carotid stenosis, mainly caused by atherosclerosis, is a narrowing or constriction of the inner surface (lumen) of the carotid artery and can result in CVD (James et al., 2013).

Various risk factors that contribute to the development of atherosclerosis have been identified. These include low-density lipoprotein cholesterol (LDL-C), blood pressure, cigarette smoke, insulin resistance, age, overweight and physical inactivity (Liapis et al., 2010).

Physical activity is recommended as a component of healthy lifestyle. Evidence have indicated that physically active individuals have lower rates of CVD (Shiroma and Lee, 2010). There is also evidence indicating that physical activity may improve the condition of carotid stenosis. Each extra 10 min of moderate to vigorous physical activity (MVPA) per day was associated with lower CIMT (Parsons et al., 2016). However, more objectively measured evidence is needed to prove the association between physical activity and carotid artery intima-media thickness (CIMT).

Sedentary behaviors are defined as any waking behavior characterized by an energy expenditure $\leq 1.5$ Metabolic Equivalents (MEIs). Studies have shown that prolonged sitting-time was positively associated with all-cause mortality (Pavey et al., 2015) and CVD risk (Chomistek et al., 2013). However, there is few studies concerning the direct relation between sedentary behaviors and CIMT based on previous studies.

Cardiorespiratory fitness (CRF) refers to the ability of the circulatory and respiratory systems to supply oxygen to skeletal muscles during sustained physical activity. Some evidence showed that CRF was negative associated with the incidence of CVD (Barker et al., 2017; Kim D and Park W, 2017) and mean CIMT in middle and early age (Mazzoni et al., 2017). However, there is no encouragement mentioned in the guideline to maintain a high level of CRF, we need more proof to verify the influence of CRF.

There is evidence suggesting manual occupation were associated with a high incidence of CVD (Robroek et al., 2017) and high levels of occupational physical activity (OPA) might result in negative health consequences (Coenen et al., 2018). Hence, it is needed to examine the associations of physical activity, sedentary time, and CRF with CIMT stratified by occupations.

Thus, the purpose of this study was to examined the associations of physical activity, sedentary time, CRF with CIMT in relatively healthy Japanese office and factory workers.

**Methods**

**Design**: a cross-sectional study using data of the baseline survey of the Toyota Motor Corporation Physical Activity and Fitness Study conducted from conducted from October 2015 to January 2016.

**Participants**: participants in this study were 1,042
Japanese male employees, aged 35–59 years from the Toyota Motor Corporation Toyota, Aichi, Japan. (Suwa et al., 2017). 152 subjects were excluded due to CHD, stork or incomplete date; Thus, 890 participants were included in the current study.

**Measures:** the CIMT was measured using ultrasound (Aplio™ 500 Platinum Series, Toshiba Medical Co, Ltd, Japan). The mean of maximal CIMT value was calculated for each participant based on 6 far wall measurements of the left and right common carotid arteries as previously described (Baldassarre et al, 2000).

The physical activity and sedentary time were measured using a tri-axial accelerometer device (HJA-750c, Omron Healthcare Co, Ltd, Japan). Participants wore the device during daily life and work hours for 10 uninterrupted days. Days with at least 600 min of wear time were considered valid (Matthews et al., 2004). Participants with at least four valid days were used in the analysis. The sedentary behavior was defined as activities ≤1.5 METs. Moderate-to-vigorous physical activity (MVPA) was defined as activities of ≥3 METs.

The maximal oxygen uptake (VO₂max) was measured using an aerobic bike (75XLIII, Konami Sports Club Co, Ltd, Japan), an indirect test of maximal aerobic power. Subjects ride on a cycle ergometer. Time to exhaustion was recorded, and an estimated VO₂max is converted by the time to exhaustion (Myles, Toft, 1982).

Health examinations also included anthropometry (body height and body mass), resting systolic and diastolic blood pressures (SBP and DBP) measurements, and blood chemistry analyses. Blood sample were tested for fasting blood sugar (FBS), triglycerides (TG), High-density lipoprotein cholesterol (HDL-C) and Low-density lipoprotein cholesterol (LDL-C). Self-administered questionnaire was conducted to assess of cigarette smoking and alcohol consumption habits (Suwa et al., 2017).

**Statistics:** participants were divided into office and factory workers according to self-reported work types. Student’s t-test was used to compare the differences of continuous variables between the two occupation groups. Pearson correlation coefficients were calculated to examine the correlations between CIMT and body composition, atherosclerotic risk factors, and physical activity, sedentary time and CRF. Multiple regression models were used to examine the associations of MVPA, sedentary time, VO₂max and CIMT. Multiple regression models were also used to examine the associations of MVPA, sedentary time, VO₂max and atherosclerosis related risk factors. Differences were considered significant when p <0.05. SAS software version 9.4 (SAS Institute Inc, Cary, NC) was used for all statistical analyses.

**Results**

Of 890 participants, 74.9% were factory workers. The mean age was 48.4, which ranged from 35-59 years. The characteristics of participants showed that factory worker had higher levels of BMI, SBP, LDL, FBS, CIMT, MVPA, and were more likely be a current smoker, but had lower level of CRF than office workers (p<0.05).

The pearson correlation coefficients analysis showed, in factory workers, CIMT was associated with LDL-C, FBS, SBP, DBP, BMI, and age. Despite the fact that the relationship between physical activity and CIMT was not significant, MVPA or VO₂max was associated with LDL-C, HDL-C, FBS, SBP, DBP, BMI, and age. The MVPA was negatively associated with sedentary time. On the other hand, in office workers, there is no significant correlations between physical activity and CIMT. CIMT was associated with FBS, SBP, DBP, BMI, and age. MVPA was associated with age. The VO₂max was associated with age, BMI and HDL-C. MVPA was no significant with sedentary time.

Results of multiple linear regression showed that, in factory workers, sedentary time was negatively association (regression coefficient, -0.00006 95% CI, -0.00011 to -0.000004) with CIMT in model 3, the adjustment factors including: LDL-C, FBS, SBP, DBP, BMI, age, smoking and alcohol drinking habits, and accelerometer wear time. However, no significant assoicitations between MVPA, CRF, and CIMT. On the
other hand, in office workers, no significant associations between sedentary time, MVPA and CMIT were found.

There was no significant association between physical activity, VO2max and atherosclerosis related risk factors in factory workers. On the other hand, in office workers, MVPA was negative associated with LDL-C (regression coefficient, -0.035; 95% CI, -0.07 to -0.0004), sedentary time was positive associated with LDL-C (regression coefficient, 0.026; 95% CI, 0.006 to 0.046). VO2max was negative associated with BMI (regression coefficient, -0.063; 95% CI, -0.088 to -0.038) and SBP (regression coefficient, -0.15; 95% CI, -0.249 to -0.05).

Discussion

This study focused on the association of objectively measured physical activity, sedentary time, and CRF with CIMT in Japanese office and factory workers.

We found that factory workers had shorter sedentary time and higher MVPA than office workers. This was consistent with previous study that laborers had a high level of MVPA among 40 occupational categories (Steeves et al., 2015). We also found that factory workers had higher CIMT, SBP, DBP, FBS, and LDL-C and lower VO2max than office workers. This was consistent with previous study that heavy industry workers have a high risk of CVD (Gray et al., 2014), CIMT was higher in manual than white-collar workers (Tedesco et al., 2017), and blue-collar workers had lower VO2 max than other occupations (Lakka et al., 1996).

The results of the present study showed sedentary time was negatively associated with CIMT in factory workers. Finding of a previous study showed higher physical workload increased the incidence of CVD in construction workers (Robroek et al., 2017). Previous study also indicated that overwork and the absence of rest are related to CVD in Asia (Lin et al., 2017). In the current study, there is a moderate correlation between sedentary time and MVPA which may indicate longer sedentary time represent more rest and lower physical workload in the factory workers.

On the other hand, we did not find any associations between physical activity or CRF with CIMT in both factory and office workers. A possible explanation for the non-significant associations could be due to the relatively healthy participants. A previous study mentioned that when the average age is below 60, the change in CIMT may not be obvious (Magnussen et al., 2003). A recent research also suggests that among the different risk factors, age is the only independent determinant of CIMT (Loboz-Rudnicka et al., 2016).

We found that MVPA was negatively associated with LDL-C, sedentary time was positively associated with LDL-C, and VO2max was negatively associated with BMI and SBP in office workers. This indicated that increasing the level of physical activity and CRF could improve arteriosclerosis related health outcomes. This was consistent with the finding of previous studies that physical activity intervention is beneficial to metabolic syndrome (Grazioli et al., 2017), longer daily sitting time is associated with an increased risk of metabolic syndrome (Bae et al., 2018), and a high level CRF has a stronger protective effect on obesity (Holtermann et al., 2017).

On the other hand, we did not find any associations of physical activity and sedentary time with arteriosclerosis-related risk factors in factory workers. We observed that factory workers have a high level of MVPA which is negatively associated with sedentary time. We speculated that the majority of the MVPA in factory could be OPA, but not LTPA. High levels of occupational physical activity (OPA) have been shown to be associated with an elevated cardiovascular risk (Coenen et al., 2018), while leisure-time physical activity (LTPA) has considerable benefits for cardiovascular health and longevity (Hallman et al., 2017). Thus, even though the factory workers had a high level of MVPA, their MVPA could not be considered the same as LTPA. As a result, the high level of MVPA in factory workers was not associated with health benefits.

From this study, attention needs to be paid to the fact that particular occupations may influence health outcomes, which the guidelines and most studies do not mention.

In conclusion, we found that 1) sedentary time was
negatively associated with CIMT in factory workers; 2) there was no significant association between physical activity and CRF with CIMT in office and factory workers; 3) MVPA was negatively associated with LDL-C, sedentary time was positively associated with LDL-C, and VO₂ max was negatively associated with BMI and SBP in office workers; and 4) there were no significant associations between physical activity, sedentary time, and CRF with arteriosclerosis-related factors in factory workers.

Main references


