Relationships between objective measurements of sedentary time and health variables in office workers: a cross-sectional analysis

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Abstract: The aim of this study was to (i) use objective measurements to assess sedentary time at work and during leisure and (ii) correlate sedentary time to blood pressure (BP), body mass index (BMI) and maximum oxygen uptake (VO_{2max}) in office workers. Tendencies towards a positive correlation between BMI and total time spent sitting (h) at work (r=0.28, P=0.06), and a tendency for a negative correlation between VO_{2max} and sitting time (h) in leisure (r=-0.23, P=0.09) were found. Objective measurements of physical activity can be used to assess sedentary time in free-living conditions.

Keywords: 24 hour measurement, accelerometer, sedentary time, white collar workers

1. Introduction

Prolonged sedentary time has long been shown to have a negative effect on health variables (Morris et al., 1953; Owen et al., 2010). A positive relationship between self-reported sedentary time at work and body mass index (BMI) has been reported by Ishizaki, et al. (2004). In addition to this, Beunza et al. found a positive relationship between self-reported sedentary time at work and blood pressure (BP) (2007). Similarly, Eaton et al. found a negative relationship between self-reported sedentary time at work and VO_{2max} (1995).

Sedentary time has mainly been investigated using self-reported data (Clark, Sugiyama, Healy, Salmon, Dunstan, & Owen, 2009; Chau, et al., 2010). However, such approach has limited validity for e.g. sitting time (Lagersted-Olsen, Korshøj, Skotte, Carneiro, Søgaard, & Holtermann, 2013). Consequently, objective measurements of sedentary time using accelerometers are found practical, reliable and valid (Reilly, Penpraze, Hislop, Davies, Grant, & Paton, 2008). Only a few studies have previously used accelerometers to measure sedentary time in office workers (Ryan et al., 2011). However, to our knowledge no studies have investigated the relationship between objectively measured sedentary time and health variables consisting of BP, BMI or VO_{2max}.

The aim of this study was to (i) measure sedentary time objectively at work and during leisure, and (ii) correlate sedentary time to BP, BMI and VO_{2max} in office workers.

2. Methods

Ninety-nine office workers were invited to participate in the study after signing the informed consent form. Eight office workers were excluded due to use of antihypertensive drugs. Furthermore, 30 office workers were excluded due to an allergic reaction to bandage or because they withdrew their consent regarding participation. Therefore, 61 office workers (36 males and 25 females, age 44.6 years ± 8.2, 80.6 kg ± 16.6, and 174.9 cm ± 8.5) participated in this study. This study was approved by the Danish Data Protection Agency and local ethics committee (H-2-2012-011), and conducted in accordance with the Declaration of Helsinki.

2.1 Physical testing

The participants were seated and relaxed for a minimum of 5 min. before measuring BP (Omron M6 Comfort, Omron Healthcare Europe B.V., Hoofddorp, Netherlands). Height and body mass (Tanita BC-543, Tanita Europe, Amsterdam, Netherlands) were measured barefooted. A bicycle ergometer (Monark Model 874E, Monark-Crescent AB, Sweden) and a handheld heart rate monitor (OxiMax™ N-65™ Handheld Pulse Oximeter, Nellcor, Covidien, Republic of Ireland) attached to index finger were used to complete submaximal VO_{2max} test (Åstrand & Ryhming, 1954). The results were adjusted for age factors in agreement with Clink & Thomas and Åstrand (1981; 1960).

2.2 Objective measurements of sedentary time

The participants were fitted with one accelerometer (ActiGraph GT3X+, ActiGraph, Pensacola, Florida, USA) placed on the anterior part of the right thigh, midway between the spina iliaca anterior superior and the patella, orientated with the x-axis pointing downwards, y-axis horizontally to the left and z-axis horizontally forward, when standing. The accelerometer was initialized using the software from the manufacturer (Actilife version 6, ActiGraph, Pensacola, Florida, USA). For more details see Skotte et al. (2014).

The participants wore the accelerometer for 4-5 consecutive days (111.4 h ± 33.2). An activity diary was used to note working and leisure time. A 15 sec. reference measurement (quiet upright standing) was made once a day to account for baseline drift of the accelerometer (Skotte et al., 2014).

2.3 Analysis of the accelerometer data

The raw data was analysed using Acti4, a custom-based-Matlab-script (The Mathworks, Natick, Massachusetts, USA) developed by the National Research Centre for the Working Environment (Copenhagen, Denmark) and Federal Institute for Occupational Safety and Health, BAuA (Berlin, Germany). The raw accelerations were low-pass filtered with a 5 Hz, 4^{th} order Butterworth filter and divided into 2 sec. intervals with a 50 % overlap (Skotte et al., 2014).

The activity diary of each participant was used to divide the data into “working time” and “leisure time”. No distinction between sitting and lying were made. Sedentary time was expressed as both absolute (h) and relative, in relation to total working time, (%) sitting time to describe sedentary time during the measuring period.

2.4 Statistical analysis

The statistical analysis was made using IBM SPSS version 20.0 (IBM, Armonk, NY, USA). A Pearson’s correlation analysis was used to describe relationship between sitting time, relative and absolute, and BP, BMI and VO_{2max}. The level of significance was set to $P<0.05$.

3. Results

There was no significant relationship between BMI and sitting time (h), (%). The working time and BMI tended to be positively correlated ($r=0.28$, $P=0.06$).

Relative sitting time total	Total sitting time (h)	Maximal sitting time leisure	Relative sitting time leisure	Sitting time leisure (h)	Leisure time (h)	Maximal sitting time work	Relative sitting time work	Sitting time work (h)	Working time (h)	BPdia (mmHg)	BPsys (mmHg)	VO_{2max} (ml O_2/min/kg)[h]		
62.4	33.0	1.47	49.7	16.1	27.6	1.20	66.9	16.9	25.4	82.9	133.4		Mean	Low[a] (n=27)
± 9.2	± 8.6	± 0.65	± 11.4	± 4.2	± 6.3	± 0.51	± 16.4	± 6.2	± 7.4	± 8.8	± 10.9		SD	
61.5	31.1	1.28	44.2	13.7	24.8	1.22	67.8	17.4	26.2	78.2	133.1		Mean	High[b] (n=27)
± 10.5	± 10.9	± 0.52	± 11.7	± 5.6	± 9.3	± 0.42	± 15.0	± 6.9	± 9.1	± 8.8	± 12.0		SD	
63.2	31.1	1.31	45.3	14.6	25.7	1.19	68.9	16.9	24.8			34.8	Mean	Normotensive[c] (n=37)
± 10.8	± 10.4	± 0.56	± 13.6	± 4.9	± 7.9	± 0.43	± 15.2	± 6.7	± 8.6			± 7.6	SD	
60.8	32.0	1.39	48.6	15.4	26.9	1.17	63.8	16.7	26.4			33.5	Mean	Hypertensive[d] (n=24)
± 10.0	± 10.3	± 0.63	± 12.7	± 5.3	± 7.6	± 0.49	± 15.6	± 6.7	± 9.0			± 8.8	SD	
62.6	28.5	1.34	47.6	14.1	24.6	1.14	66.8	15.0	22.6	78.0	129.1	36.2	Mean	Normal[e] (n=28)
± 11.9	± 11.9	± 0.56	± 17.1	± 5.4	± 8.8	± 0.46	± 17.9	± 7.9	± 9.4	± 8.6	± 10.2	± 7.5	SD	
61.3	33.8	1.34	44.8	15.3	27.4	1.26	67.5	18.5	27.7	85.4	137.8	34.2	Mean	Overweight[f] (n=21)
± 6.55	± 8.8	± 0.61	± 10.1	± 5.17	± 7.1	± 0.46	± 12.6	± 5.5	± 7.2	± 10.7	± 12.6	± 8.8	SD	
63.1	34.3	1.35	47.3	16.3	27.6	1.33	66.3	18.0	28.1	85.1	139.1	29.4	Mean	Obese[g] (n=12)
± 12.9	± 7.1	± 0.64	± 6.7	± 3.9	± 5.81	± 0.43	± 14.9	± 4.2	± 7.8	± 9.5	± 9.8	± 5.5	SD	

Table 3: The characteristics of the VO2max-groups "Low" and "High", BP-groups "Normotensive" and "Hypertensive", and the BMI-groups "Normal", "Overweight" and "Obese". a) Are the below the median, equal to a $VO_{2max} \leq 32.6$. b) Are the above the median, equal to a $VO_{2max} \geq 32.6$. c) Normotensive is defined as blood pressure < 140 mmHg systolic and < 90 mmHg diastolic. d) Hypertensive is defined as blood pressure either > 139 mmHg systolic or > 89 mmHg diastolic. e) Normal is defined as $18.5 \leq BMI \leq 24.9$. f) Overweight is defined as $24.9 < BMI \leq 29.9$. g) Obese is defined as BMI > 29.9. h) VO_{2max} only includes 35 subjects in Pre-hypertensive and 19 subjects in Hypertensive.

There were no significant relationships between sitting time (h), (%) and BP (cf. table 1).

Similar to the other health variables, no significant relationship was found between sedentary time and VO_{2max}. However we found tendencies towards negative relationships between both absolute sitting time in leisure, relative sitting time in leisure and $VO2_{max}$ (r=-0.23, P=0.09, r=-0.24, P=0.09, respectively).

4. Discussion

4.1 Methodological considerations
In recent years, the use of objective data to describe physical activity has become more frequent. As such, accelerometer recordings similar to the ones used in this study enable to determine different type of movement like sitting or standing in field studies (Skotte et al., 2014). In this study, the sedentary time of 61 office workers was measured at work and during leisure time in relation to health variables. The use of a single accelerometer on the thigh did not enable differentiation between sitting and lying. Furthermore, we only focused on sedentary periods. Future studies integrating larger population sizes (Jørgensen, et al., 2013) and applying multiple logistic regressions with adjustment for potential confounders like gender, age are needed to confirm the tendencies found in this study.

4.2 Health Variables
No significant relationship was found between sedentary time and BMI. This is in contradiction with a previous study reporting that prolonged uninterrupted periods of sedentary time have deleterious effects on waist circumference, BMI and triglycerides (Healy, et al., 2008). A study conducted by Holtermann et al. has shown a relationship between VO_{2max} and BMI (2010). The latter is in agreement with the reported tendencies linking BMI and VO_{2max}. Both prolonged sitting time leisure and relative sitting time during leisure tended to be related to lower VO_{2max} in line with (Bruce et al., 1973).
We did not find significant relationship between the amount of time spent sedentary at work or during leisure with BP. This is opposite to the findings of Beunza et al. (2007), showing that both self-reported sedentary time and interactive sedentary time are associated with a higher risk of hypertension. Wijndaele et al. have reported that an increase in time spent watching television result in increased BP diastole for women (2010). However, self-reported data of sitting time have low validity (Lagersted-Olsen et al. 2013).

4.3 Working time versus leisure time
Sedentary time occurs for a varying amount of time every day, but when this behaviour accumulates over weeks, months or years, it may have negative influences on health (Pronk, 2010). In the present study, sedentary time during leisure time tended to be negatively linked to VO_{2max}. This may indicate that VO_{2max} is more affected by the sedentary time during leisure than the sedentary time at work. Similarly, a tendency toward positive relationship between the duration of sitting time and BMI was found suggesting the interlink between sitting time during work and health.

5. Conclusion

This study did not find significant relationships between sedentary time and VO_{2max}, BP or BMI. This can be due to the lack of exposure contrast in this group of office workers.

Objective measurements of physical activity based on accelerometer are useful for the detection of sedentary time in free-living conditions. Future studies with larger population sizes using multiple logistic regressions models are warranted.

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