Desk-based occupational sitting patterns: Weight-related health outcomes

Ryde, Gemma C.; Brown, Helen E.; Peeters, G. M.E.E.; Gilson, Nicholas D.; Brown, Wendy J.

Published in:
American Journal of Preventive Medicine

DOI:
10.1016/j.amepre.2013.05.018

Desk-Based Occupational Sitting Patterns

Weight-Related Health Outcomes

Gemma C Ryde, BSc, Helen E Brown, MSc, G.M.E.E. (Geeske) Peeters, PhD, Nicholas D Gilson, PhD and Wendy J Brown, PhD.

From School of Human Movement Studies (Ryde, Brown, Peeters, Gilson, Brown), The University of Queensland, St Lucia Campus, Brisbane, Australia

Address correspondence to: Gemma Ryde, RG Bomont Building, University of Stirling, Stirling, FK9 4 LA, Scotland. E-mail: gemma.ryde@stir.ac.uk.

This is a post-print version of the following article: Ryde, Gemma C., Brown, Helen E., Peeters, G. M. E. E., Gilson, Nicholas D. and Brown, Wendy J. (2013) Desk-Based Occupational Sitting Patterns Weight-Related Health Outcomes. American Journal of Preventive Medicine, 45 4: 448-452.

Background: Prolonged, uninterrupted sitting time is associated with poor health outcomes. As most sitting time occurs at work, accurate, objective measurement of occupational sitting patterns is required to fully understand its effects on employee health.

Purpose: The purpose of this study was to examine associations between desk-based sitting patterns, waist circumference (WC) and body mass index (BMI).

Methods: Participants were full-time, office-based employees (N=105; mean age 40.9±11.5 years; BMI 26.1±3.9, 65% women). Sitting patterns (total desk-based sitting time and number of times employees got up from their desk) were assessed for five days using an objective measure of desk-based sitting, the sitting pad. WC, height and weight were measured, and BMI calculated (weight/height^2). Associations between sitting patterns, WC and BMI were tested using logistic regression models. Data were collected and analysed between 2011/12.

Results: Those with high sitting time at their desk were 2.7 times (95% CI: 1.3 to 6.3) more likely to have WC ≥94 cm (men) or ≥80cm (women), and 9.0 times (95% CI: 1.9 to 41.9) more likely to have BMI ≥30 than those with lower sitting time. There were no significant associations between the number of times employees got up from sitting at their desk and WC or BMI.

Conclusion: High desk-based sitting time was associated with increased likelihood of weight related health outcomes whereas frequency of getting up from sitting at the desk was not.

Introduction

Prolonged periods of sedentary time (primarily sitting) are associated with increased mortality, metabolic syndrome and cardiovascular disease.[1-7] There are indications that not only is total sedentary time important, but also how this time is accumulated throughout the day. Previous studies have shown that frequent interruptions in sedentary time may be associated with beneficial health outcomes,[8,9] suggesting that breaking up sedentary time may offset the detrimental effects of high total sedentary time.

With 66% of daily sitting occurring at work, the potential health effects for employees exposed to high volumes of occupational sitting is an area of interest.[10] Previous studies that have assessed the health effects of occupational sitting primarily used self-report measures which cannot accurately report individual sitting patterns (sitting time and interruptions to sitting).[11,12] Accelerometers are commonly used to provide an objective measure of activity patterns and sedentary behaviour. However, they cannot distinguish between sitting and standing still.[13-15] In order to report accurately on the relationship between occupational *sitting patterns* and health outcomes, objective measures that measure postural change are needed.

A device has been developed called the sitting pad (SP), which accurately measures desk-based sitting patterns.[16] A recent study using this device showed that almost two thirds of administrative employees' working hours are spent sitting at their own desk.[17] It is therefore plausible that desk-based sitting may contribute to any negative health effects associated with occupational sitting. The aim of this study was therefore to examine the associations between desk-based sitting patterns with WC and BMI.

Methods

Study design and participants

Full time employees from five organisations (mostly state and local government) in urban Brisbane, Australia, took part in this cross-sectional study. Study information was disseminated to approximately 2500 employees through internal distribution channels with the aim of recruiting around 200 employees.

The study consisted of an anthropometric assessment, seven day collection of objectively measured desk-based sitting time and physical activity, and an online survey. Consent was signed prior to the anthropometric assessment. Data were collected and analysed from October 2011 till July 2012. Study protocols were approved by the Human Research Ethics Committee of The University of Queensland, Australia.

Anthropometric measurement

Anthropometric assessments were conducted by trained researchers, using standardised protocols. Height was measured with a portable stadiometer (Seca 213, Seca, UK), and weight using digital scales (Nuweigh LOG842, USA). BMI was calculated as weight (kg)/ height^2 (m^2) and dichotomized, with ≥30 (obese) defined as high risk. WC was measured using a flexible steel tape (Lufkin W606PM, USA), and high risk was defined as ≥94cm for men and ≥80cm for women.[18]

Diary data and survey

A seven day diary was provided for employees to record work start and finish times. Participants were also asked to record whether they were predominantly sitting at their desk for each work day. Employees were sent a link via email to an online demographic survey (LimeSurvey, version 1.92; Build 120330) that included questions about age, qualification, smoking status, health status and annual income. Time spent at work was calculated from diary data.

Sitting time and physical activity measurement

Desk-based sitting time and sit to stand transitions (STS, i.e. the *number* of times employees got up from siting at their desk) were measured using the SP. It comprises a cushion placed on the office chair containing a pressure sensor to detect transitions to and from sitting. A microcontroller then records a time stamp to the second for each sitting and standing event. The SP has been previously validated elsewhere.[16] SPs were fitted by researchers to employee's office chairs on the day of the anthropometric assessment. SP data were downloaded using a proprietary software package which produces a spread sheet output of raw data (Microsoft Excel 2007). Only days with both diary and SP data were included, and days when employees reported they were not predominantly sitting at their desks (e.g. working from home) were excluded from analyses. Diary recorded work time of ≥6 hours per day was classified as a valid work day, with three or more valid work days required for analyses to represent the majority of the working week. Desk-based sitting time and STS, were calculated for each employee, and dichotomised on the medians (high desk-based sitting time ≥352.15mins/day; low desk-based STS ≤26/day).

ActiGraph GT3X+ (AG) were used to assess employees' moderate to vigorous physical activity (MVPA). Detailed methods on AG data collection and handling for this cross-sectional study have been described in full elsewhere.[19] For the purpose of this paper, data were categorised into MVPA using established cut points and presented as average total MVPA (weekday and weekend) and MVPA at work.[15,20] MVPA was dichotomised as < or ≥ 30 minutes per day for use in the interaction analyses.

Statistical analyses

All data were analysed using SPSS (IBM SPSS Statistics v20.0.0). Continuous sample characteristics were presented as means ± standard deviations (SD) and categorical data were presented as number and proportions. Differences in participant characteristics between high and low desk-based sitting and high and low STS were analysed using Chi-squared tests for categorical and t-tests for continuous variables. Associations between desk-based sitting and desk-based STS with WC and BMI were tested using logistic regression models. Logistic regression was appropriate as categorization of sitting time improved the distribution of residuals so that assumptions for linearity were met. The models were analysed unadjusted and with adjustment for those confounders which led to a change in the regression coefficient of more than 10%. Potential confounders were sex, age, MVPA, annual income, and qualification. Only age and sex met the criteria for confounding and were included in the adjusted models. Interaction effects of MVPA in the associations between desk-based sitting time, STS and WC and BMI were tested by adding interaction terms to the respective models (i.e. sitting*MVPA and STS*MVPA). Significance level was set at <0.1 for interactions and at <0.05 for all other analysis.

Results

Of the 180 employees who expressed interest in the study, 157 met the inclusion criteria and signed informed consent, with 151 completing the anthropometric measures. Almost one third of employees (n=46) were excluded owing to insufficient SP and diary matched days, leaving 105 who provided data for analyses. Characteristics for the total analysis sample and by desk-based sitting patterns are presented in Table 1. Mean age was 40.9±11.5 years and 65% of participants were women. Most employees were non-smokers (53%), with 51% rating their own health as very good or excellent. Participants worked 8.7 ± 0.8 hours/day on average, of which 67% was spent sitting at their own desk (SP; 5.8 ± 1.2 hours/day). Employees got up from sitting at their desk approximately three times every hour of work (SP; STS 29 ±13). Average MVPA at work was 16.8 ± 13.2 minutes per day (AG).

Significant differences were found between high and low desk-based sitting for WC (p=0.01) and BMI (p=0.02), with high sitting associated with a 6.1cm larger WC and a 1.8kg/m^2 higher BMI. There were no statistically significant differences between low and high desk-based STS for WC or BMI. Also, there were no statistically significant differences between employees in the high and low desk-based sitting groups or low and high STS groups for any of the demographic characteristics or for MVPA, total or at work (See Table 1).

Relationships between desk-based sitting time and STS with risk of high WC and BMI are shown in Table 2. Interaction effects of MVPA in these associations were found to be significant in only one of the four associations tested (sitting time and BMI; p=0.05). For other associations the p-values ranged from 0.17 to 0.81. As this single significant interaction might be due to chance and for reasons of sample size and consistency, further analyses were not stratified for MVPA. In unadjusted models, those with high desk-based sitting time were 2.8 times (95% CI: 1.3 to 6.3) more likely to have a high risk WC and 9.0 times (95% CI: 1.9 to 41.9) more likely to have a high BMI than low desk-based sitters. After adjustment for confounders, these associations were largely unchanged. For desk-based STS, there were no associations with WC or BMI.

Discussion

The aim of this study was to examine the associations between desk-based sitting patterns, WC and BMI. The findings suggest that, for this sample, those with high desk-based sitting time are more likely to have high WC and BMI, than those who sit for less time at their desks. However, frequency of getting up from sitting at the desk was not significantly associated with WC or BMI.

While not specific to the workplace or measuring postural allocation, several studies have shown relationships with accelerometer measured daily sedentary time with WC and BMI.[9,21-26] For example, British researchers reported that each additional hour of sedentary time is associated with a 1.89cm larger WC in 30 to 80 year olds with newly diagnosed type 2 diabetes.[22] Although accelerometers may not directly measure sitting, these cumulative findings suggest associations between sedentary time and WC and BMI.

Unexpectedly, the findings did not show that frequent interruptions to sitting time lessened the association with high WC or BMI. Other studies have however shown favourable associations between accelerometer measured interruptions to sedentary time with WC[8,9,22] and BMI.[8] Healy et al.[8] reported significant associations between interruptions in sedentary time and both outcomes, with the highest quartile of interruptions associated with an 5.9cm lower WC than those in the lowest quartile. Similarly, Cooper et al. (2012) also reported a 0.15cm lower WC for each interruption in sedentary time.[22]

The contrasting evidence between the findings in the present study and those that use accelerometers could be explained by the different methods used to assess an ‘interruption’. In the present study, STS were measured by recording each postural change from sitting to standing while with accelerometer data, each minute of activity data is aggregated and an interruption defined as a change in activity threshold from sedentary to light intensity across consecutive minutes.[8,9] Postural devices and accelerometers may therefore be measuring related, but fundamentally different activities in regards to interruptions, with this measurement variability possibly impacting on associations with health outcomes.

The use of the SP to objectively measure both sitting time postural change is a strength of this study. Other study strengths include recruiting participants from real office settings, and using multiple assessment measures. However, this latter point may have contributed to participant burden and a subsequent small sample size, creating large confidence intervals and lack of power to detect statistically significant associations using continuous variables. The sample size may also limit the generalisability of the results. This study should therefore be replicated in other office based settings and workplaces.

Although the present study showed significant positive associations between desk-based sitting time and indicators of weight related health outcomes, owing to the cross-sectional study design, no inference can be made about causality; does prolonged sitting time cause increases in WC and BMI, or do employees with high WC and BMI sit more or choose occupations with less activity? To answer these questions studies with longitudinal or experimental designs, larger samples and objective measures of occupational sitting, will be required.

Conclusion

This study provides preliminary evidence to suggest that high desk-based sitting time, as measured by the SP, was associated with having a high-risk WC and BMI. These findings highlight desk-based sitting as a potential context for intervention. However, frequent interruptions were not associated with either outcome. The relationship between interrupting occupational sitting and health outcomes requires further investigation.

Acknowledgements

Gemma C Ryde: is funded by The University of Queensland postgraduate scholarship scheme and has no financial disclosures.

Helen E Brown: is funded by The University of Queensland postgraduate scholarship scheme and has no financial disclosures.

Nicholas D Gilson: Has no financial disclosures.

G.M.E.E. (Geeske) Peeters: Has no financial disclosures.

Wendy J Brown: is funded by NHMRC program grant (#569940) and has no financial disclosures.

No financial disclosures were reported by the authors of this paper.

References

1. Dunstan DW, Thorp AA, Healy GN. Prolonged sitting: is it a distinct coronary heart disease risk factor? *Curr Opin Cardiol.* 2011;26(5):412-419.
2. Katzmarzyk PT, Church TS, Craig CL, Bouchard C. Sitting time and mortality from all causes, cardiovascular disease, and cancer. *Med Sci Sporst Exerc.* May 2009;41(5):998-1005.
3. Katzmarzyk PT, Lee IM. Sedentary behaviour and life expectancy in the USA: a cause-deleted life table analysis. *BMJ open.* 2012;2: e000828. doi:10.1136/ bmjopen-2012-000828.
4. Thorp AA, Owen N, Neuhaus M, Dunstan DW. Sedentary behaviors and subsequent health outcomes in adults a systematic review of longitudinal studies, 1996-2011. *Am J Prev Med.* Aug 2011;41(2):207-215.
5. Proper KI, Singh AS, van Mechelen W, Chinapaw MJ. Sedentary behaviors and health outcomes among adults: a systematic review of prospective studies. *Am J Prev Med.* Feb 2011;40(2):174-182.
6. van der Ploeg HP, Chey T, Korda RJ, Banks E, Bauman A. Sitting time and all-cause mortality risk in 222 497 Australian adults. *Arch Intern Med.* Mar 26 2012;172(6):494-500.
7. Wilmot EG, Edwardson CL, Achana FA, Davies MJ, Gorely T, Gray LJ, et al. Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. *Diabetologia.* Nov 2012;55(11):2895-2905.
8. Healy GN, Dunstan DW, Salmon J, Cerin E, Shaw JE, Zimmet PZ, et al. Breaks in sedentary time - Beneficial associations with metabolic risk. *Diabetes Care.* 2008;31(4):661-666.

9. Healy GN, Matthews CE, Dunstan DW, Winkler EA, Owen N. Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003-06. *Eur Heart J.* Mar 2011;32(5):590-597.
10. Ryan CG, Dall PM, Granat MH, Grant PM. Sitting patterns at work: objective measurement of adherence to current recommendations. *Ergonomics.* 2011;54(6):531-538.
11. Clark BK, Thorp AA, Winkler EA, Gardiner PA, Healy GN, Owen N, et al. Validity of self-reported measures of workplace sitting time and breaks in sitting time. *Med Sci Sports Exerc.* Oct 2011;43(10):1907-1912.
12. Van Uffelen JG, Wong J, Chau JY, van der Ploeg HP, Riphagen I, Gilson ND, et al. Associations between occupational sitting and health risks: a systematic review. *Am J Prev Med.* 2010;39(4):379-388.
13. Lyden K, Kozey Keadle SL, Staudenmayer JW, Freedson PS. Validity of two wearable monitors to estimate breaks from sedentary time. *Med Sci Sports Exerc.* Nov 2012;44(11):2243-2252.
14. Healy GN, Clark BK, Winkler EA, Gardiner PA, Brown WJ, Matthews CE. Measurement of adults' sedentary time in population-based studies. *Am J Prev Med.* 2011;41(2):216-227.
15. Kozey-Keadle S, Libertine A, Lyden K, Staudenmayer J, Freedson PS. Validation of wearable monitors for assessing sedentary behavior. *Med Sci Sports Exerc.* Aug 2011;43(8):1561-1567.
16. Ryde GC, Suppini A, Gilson GD, Brown WJ. Validation of a novel, objective measure of occupational sitting *J Occup Health.* 2012;54:383-386.
17. Ryde GC, Brown HE, Gilson ND, Brown WJ. Are we chained to our desks? Assessing desk based sitting using a new objective measure of occupational sitting time. Paper

presented at: 4th International congress of physical activity and public health. 2012; Sydney.

18. World Health Organisation. Obesity: Preventing and managing the global epidemic. *Report of a WHO consultation, World Health Organization Technical Report Series. World Health Organization, Geneva, pp. i-xii, 1-253.* 2000.
19. Brown HE, Ryde GC, Gilson GD, Burton NW, Brown WJ. Objectively measured sedentary behaviour and physical activity in office employees: relationships with presenteeism. *J Occup Environ Med.* 2013. In press.
20. Sasaki JE, John D, Freedson PS. Validation and comparison of ActiGraph activity monitors. *J Sci Med Sport.* Sep 2011;14(5):411-416.
21. Lynch BM, Friedenreich CM, Winkler EA, Healy GN, Vallance JK, Eakin EG, et al. Associations of objectively assessed physical activity and sedentary time with biomarkers of breast cancer risk in postmenopausal women: findings from NHANES (2003-2006). *Breast Cancer Res Treat.* Nov 2011;130(1):183-194.
22. Cooper AR, Sebire S, Montgomery AA, Peters TJ, Sharp DJ, Jackson N, et al. Sedentary time, breaks in sedentary time and metabolic variables in people with newly diagnosed type 2 diabetes. *Diabetologia.* Mar 2012;55(3):589-599.
23. Bankoski A, Harris TB, McClain JJ, Brychta RJ, Caserotti P, Chen KY, et al. Sedentary activity associated with metabolic syndrome independent of physical activity. *Diabetes Care.* Feb 2011;34(2):497-503.
24. Healy GN, Wijndaele K, Dunstan DW, Shaw JE, Salmon J, Zimmet PZ, et al. Objectively Measured Sedentary Time, Physical Activity, and Metabolic Risk The Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Diabetes Care.* Feb 2008;31(2):369-371.

25. Ekelund U, Brage S, Besson H, Sharp S, Wareham NJ. Time spent being sedentary and weight gain in healthy adults: reverse or bidirectional causality? *Am J Clin Nutr.* Sep 2008;88(3):612-617.
26. Scheers T, Philippaerts R, Lefevre J. Variability in physical activity patterns as measured by the SenseWear Armband: how many days are needed? *Eur J Appl Physiol.* May 2012;112(5):1653-1662.

Table 1. Characteristics for the total analysis sample, and by desk-based sitting patterns.

Characteristics	Total	High sitting desk	Low sitting desk	p value	High STS desk	Low STS desk	p value
Age (years) (n=105) mean ± SD	40.9 ± 11.5	42.6 ± 10.8	39.1 ± 12.0	0.11	41.9 ± 12.0	39.8 ± 11.0	0.34
Sex (n=105) n (%)				0.60			0.34
Male	37 (35.2)	20 (37.7)	17 (32.7)		16 (30.8)	21 (39.6)	
Female	68 (64.8)	33 (62.3)	35 (67.3)		36 (69.2)	32 (60.4)	
Qualification (n=89) n (%)				0.07			0.12
No formal after school qualifications	15(16.9)	10 (21.7)	5 (11.6)		9 (20.0)	6 (13.6)	
Certificate / diploma	41(46.1)	24 (52.2)	17 (39.5)		24 (53.3)	17 (38.6)	
University degree or higher	33(37.1)	12 (26.1)	21 (48.8)		12 (26.7)	21 (47.7)	
Annual income ($AUS) (n=88) n (%)				0.27			0.12
<$60k	26(29.5)	15 (33.3)	11 (25.6)		17 (38.6)	9 (20.5)	
$60-80k	40(45.5)	22 (48.9)	18 (41.9)		19 (43.2)	21 (47.7)	
>$80k	22(25.0)	8 (17.8)	14 (32.6)		8 (18.2)	14 (31.8)	
BMI (n=105) mean ± SD	26.1 ± 3.9	27.0 ± 3.2	25.2 ± 3.2	0.02	26.0 ± 3.9	26.3 ± 0.69	0.69
Waist circumference (cm) (n=104) mean ± SD	83.8 ± 11.4	86.8 ± 12.0	80.7 ± 9.9	0.01	83.1 ± 11.4	84.5 ± 11.4	0.55
Physical activity mean ± SD							
Total MVPA (n=90) (mins/day)	44.3 ± 25.3	41.1 ± 25.5	48.1 ± 24.8	0.20	44.8 ± 25.8	43.8 ± 25.1	0.86
MVPA at work (n=97) (mins/day)	16.8 ± 13.2	14.9 ± 13.2	18.9 ± 15.8	0.14	17.1 ± 16.0	16.5 ± 9.9	0.83

Average daily desk-based sitting and STS dichotomised on the median (high desk-based sitting time ≥352.15mins; low desk-based STS ≤26).

	Total	High waist circumference	Crude	Adjusted	Total	High BMI	Crude	Adjusted
	n	n(%)	RR(95% CI)	RR(95% CI)	n	n(%)	RR(95% CI)	RR(95% CI)
Desk-based								

sitting time								
Low (ref)	51	17 (35.4)	1.00	1.00	52	2 (12.5)	1.00	1.00
High	53	31 (64.6)	2.82 (1.27 to 6.26)	2.69 (1.17 to 6.19)	53	14 (87.5)	8.97 (1.93 to 41.85)	8.95 (1.87 to 42.85)
Desk-based STS								
High (ref)	52	24 (50.0)	1.00	1.00	52	8 (50.0)	1.00	1.00
Low	52	24 (50.0)	1.00 (0.46 to 2.16)	1.13 (0.50 to 2.55)	53	8 (50.0)	0.98 (0.34 to 2.84)	0.90 (0.30 to 2.69)

Table 2. Association of desk-based sitting time and sit to stand transitions (STS) with high-risk waist circumference and BMI.

High waist circumference categories (n=104) (men ≥94cm; women ≥80cm)

High BMI (n=105) (≥30)

Sitting variables were dichotomised on the median (High desk-based sitting ≥352.15mins; low desk-based STS ≤26)

Adjusted model: All models adjusted for age and sex