VALIDITY OF SELF-REPORT MEASURES OF WORKPLACE SITTING TIME AND BREAKS IN SITTING TIME

Clark BK[1], Thorp A[2], Winkler E[1], Gardiner PA[1], Healy GN[1,2], Owen N[1,2],Dunstan DW[1,2,3,4,5]

[1]The University of Queensland, School of Population Health, Cancer Prevention Research Centre, Brisbane, Australia

[2]Baker IDI Heart and Diabetes Institute, Melbourne, Australia

[3]School of Exercise and Nutrition Sciences, Deakin University, Melbourne, Australia

[4]Vario Health Institute, Edith Cowan University, Perth, Australia

[5]Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Australia

Corresponding Author

Bronwyn K Clark

Cancer Prevention Research Centre

School of Population Health

The University of Queensland

Herston Road, Herston, QLD 4006 Australia

E-mail: b.clark3@uq.edu.au

Phone: 61-7-3365-5528

Fax: 61-7-3365-5140

Funding: This study was supported by funding from Queensland Health and the National Health and Medical Research Council of Australia (#301200).

The authors wish to acknowledge the Victorian Health Promotion Foundation, VECCI and Medibank Private for their generous financial support to undertake the study and express our gratitude to the employees who volunteered their time to participate in the study.

Inclusions:

Abstract (word count: 275)

Number of tables for text: 1

Number of figures: 1

Date of Submission: 4 February, 2011

Running Head

Validity of a workplace sitting questionnaire

Abstract

Purpose: In order to understand the prevalence and potential health impact of prolonged workplace sedentary (sitting) time, valid measures are required. Here, we examined the criterion validity of a brief self-report measure of workplace sitting time and breaks in sitting time.

Methods: An interviewer-administered questionnaire was used to assess workplace sitting time (hrs/day) and breaks from sitting per hour at work in a convenience sample of 121 full-time workers (36% men, mean age: 37 years, 53% office based). These self-report measures were compared to accelerometer-derived sedentary time (hrs/day <100 counts/min) and breaks per sedentary hour (number of times counts ≥100/min) during work hours.

Results: Self-reported sitting time was significantly correlated with accelerometer-derived sedentary time (Pearson's r=0.39, 95%CI 0.22, 0.53), with average sitting time 0.45hrs/day higher than average sedentary time. Bland-Altman plots and regression analysis showed positive associations between the difference in sitting and sedentary time, and the average of sitting and sedentary time (mean difference=-2.75 hours + 0.47 x average sitting and sedentary time; limits of agreement +/-2.25hrs/day). The correlation of self-reported breaks per sitting hour with accelerometer-derived breaks per sedentary hour was also statistically significant (Spearman's r_s=0.26, 95%CI: 0.11, 0.44).

Conclusions: This study is the first to examine the criterion validity of an interviewer-administered questionnaire measure of workplace sitting time and breaks in sitting time using objective criterion measures. The workplace sitting measure has acceptable properties for use in observational studies concerned with sedentary behavior in groups of workers; however, the

wide limits of agreement suggest caution in estimating individuals' sitting time with high precision. Using self-report measures to capture patterns of workplace sitting (such as breaks in sitting time) requires further development.

Key words: questionnaire, sedentary behavior, working, adults, measurement, accelerometer

Introduction

Paragraph 1 Health consequences of prolonged time spent sitting have been identified, with detrimental associations shown for premature mortality, incident type 2 diabetes and biomarkers of cardio-metabolic health (7, 11, 13, 14). Furthermore, there is emerging evidence from studies using objective measures (accelerometer) that the manner in which sedentary time is accumulated can also be important, with less-frequent breaks (interruptions) in sedentary time being adversely associated with cardio-metabolic risk biomarkers, independent of the total time spent sedentary (10, 12).

Paragraph 2 The workplace has been identified as a key setting for health-promotion interventions (4, 6), with the reduction of prolonged sitting time specifically identified as a priority by the Australian National Preventive Health Taskforce (19) and the American Heart Association (4). A recent review of on occupational sitting and health risks found that there was some evidence for associations with body mass index and cancer cross-sectionally; and mortality and Type 2 diabetes prospectively (23). Arising from this review, one of the key recommendations for future research was the inclusion of measures of occupational sitting time with demonstrated reliability and validity for examination of a dose response (23). In particular, reliable and valid self-report measures are needed, as cost and feasibility concerns around objective measures such as accelerometers or inclinometers can preclude their use. Though the reliability of self-report indices of workplace sitting to date is reasonably good (Intraclass correlation: 0.76-0.86) (15, 17, 18, 24), their validity against an objective criterion has not yet been established although one study has compared a questionnaire measure of workplace sitting to an activity log criterion (15).

Paragraph 3 We examined the validity of a new interviewer-administered questionnaire measure of workplace sitting time and breaks in sitting time using accelerometer-derived sedentary time and breaks per sedentary hour as the relevant criterion measures.

Methods

Paragraph 4 The *Stand Up Australia* study was conducted from November 2008-March 2009. Recruitment for the study took place in four organizations based in Melbourne, Australia. Recruitment emails were disseminated by Human Resource representatives within each of the organizations to eligible persons working in office, customer service (shop front claims processing) and call centre settings. The Ethics Committee of the Baker IDI Heart and Diabetes Institute approved the study, and written informed consent was obtained from the organizations and employees involved.

Paragraph 5 A total of 193 consented to participate and attended an initial interview (visit 1) at their workplace where demographic information (age, gender, marital status, education history, job title) was collected by an interviewer-administered questionnaire. Height and weight were measured using standard protocols to derive body mass index (BMI; kg/m^2) and instruction on accelerometer use and activity log completion was provided. Participants were required to wear an accelerometer (GT1M – www.theactigraph.com) over the right iliac crest during waking hours. Accelerometer data was collected in one minute epochs. Participants also were required to complete an activity log, which included recording accelerometer wear time and work start and finish times (used to derive work hours and work days), for seven days following visit 1.

Paragraph 6 Visit 2 took place at the end of the seven-day period (day 8) again at the participants' workplace. At visit 2, the accelerometer and completed activity log were returned and participants completed a questionnaire which collected information on physical activity and sitting time. Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ). Sitting items included the workplace sitting and breaks in sitting items reported in this paper and additional questions on television viewing time, computer use and total sitting time that were similar to questions previously reported in the literature television and computer use (22); total sitting time (5)). The questionnaire was interviewer-administered for all but one organization, where the visit 2 questionnaire was self-completed.

Participants

Paragraph 7 The criteria for recruitment included being aged between 18-65 years, ambulatory (i.e. not wheel-chair bound), and employed full-time. Participants were considered to have valid data if they provided complete responses to the interviewer-administered workplace sitting time and breaks in sitting time questions; and, they had worn the accelerometer during work hours, identified in the activity log, for at least four days. Of the 193 participants recruited, 185 completed the Visit 2 questionnaire. One organization was excluded due to the self-completion of the questionnaire (n=29) and a further 35 participants did not provide valid accelerometer data. The final sample consisted of 121 (63% of those originally recruited) participants from three organizations across six workplaces in three work settings: office (three workplaces), call centre (two workplaces), and customer service (one workplace).Visit 2 was scheduled such that the seven-day recall period of the self-report sitting and breaks questions would match the period of accelerometer wear. Of the participants with valid data, 88% (n=107) completed Visit 2 and

the accelerometer component as scheduled; the remaining participants completed the visit 2 questionnaire 1 – 7 days later than planned, and therefore their period of self-report did not cover the full period of workplace accelerometer wear. Data for the participants who completed the Visit 2 questionnaire later were included as no difference in results was observed with and without this group.

Paragraph 8 The age and gender characteristics of those who were initially recruited compared to the broader workplace were not different except among customer service workers for whom men were over-represented in the recruited sample (men 27% in recruited group, 6% in non-recruited group; Chi square $p<0.001$). There was no significant difference in gender profile, mean age, BMI, education level, meeting physical activity guidelines or work setting between the recruited participants who did and did not provide valid data.

Measures

Paragraph 9 Self-reported workplace sitting time: Workplace sitting was obtained from the following question: *'Please estimate the total time during the last week that you spent sitting down as part of your job while at work or working from home?'* Participants reported their sitting time separately for work days and non-work days in hours and minutes (see Appendix, SDC 1, Questions for work sitting and breaks in sitting time). The average daily time spent sitting for work on workdays (hrs/day) was then calculated using reported number of work days.

Paragraph 10 Accelerometer-derived workplace sedentary time: Accelerometer-derived workplace sedentary time was calculated as time spent at an activity level of <100 counts per minute (cpm) during work hours. Work hours were identified by the participant-completed activity log. This level of activity typically includes behaviors such as sitting or working quietly

(e.g. computer) (16). Sum totals of this time (expressed as hours) were divided by the number of work days to calculate workplace sedentary time in hours per day. As per participant instruction, it was assumed that the accelerometer was not removed during work hours.

Paragraph 11 Self-reported breaks in workplace sitting time: The number of breaks in sitting time was obtained by the following question: '*How many breaks from sitting (such as standing up, or stretching or taking a short walk) during one hour of sitting would you typically take at work?*' A choice of responses (0, 1, 2, 3, 4 and 5 or more) was given (see Appendix, SDC 1, Questions for work sitting and breaks in sitting time).

Paragraph 12 Accelerometer-derived breaks in workplace sedentary time: Breaks in sedentary time were defined as any period of time that the accelerometer recorded activity transitioned from sedentary (<100 counts per minute (cpm)) to active (≥100 cpm). The duration of the break was the length of time the accelerometer registered counts above this threshold. The number of breaks recorded during sedentary time were expressed as breaks per sedentary hour, calculated as total breaks/total sedentary time (hours) as suggested in Healy *et al.* (10). Total breaks and total sedentary time for all work time during the week on valid work days were used to calculate this summary measure.

Statistical analyses

Paragraph 13 Analyses were conducted in SPSS version 17.0 (SPSS, Inc. Chicago IL) and STATA version 11 (StataCorp LP, College Station, TX, USA) with significance set at $p<0.05$. Data are presented for both the total sample and stratified by work setting (office-based, call centre and customer service), as patterns of sedentary time varied across each setting. Characteristics of the sample were described as % (n), median (25%, 75%) or mean (standard

deviation). The relationship between self-reported workplace sitting and accelerometer-derived sedentary time was examined using Pearson's correlation (r_p) although Spearman's correlations are also included for comparison with previous results from IPAQ. Unlike the sitting and sedentary time measures, the distribution of the self-reported breaks variable was not normal, therefore Spearman's rank order correlation (r_s) was used to examine the correlation between self-reported workplace breaks in sitting and accelerometer-derived breaks per sedentary hour. The 95% confidence intervals for the correlations (r_p, r_s) were calculated using Fisher's transformation.

Paragraph 14 Agreement between self-reported workplace sitting time and accelerometer-derived workplace sedentary time in the total sample was examined using the method outlined by Bland and Altman (2). Plots with mean difference and limits of agreement (+/- 1.96 SD) are presented. Linear regression was used to check whether the mean difference and limits of agreement varied across average values of sitting and sedentary time ((sitting + sedentary time)/2) (3). Agreement between the measures of workplace breaks was not assessed as the workplace sitting breaks question has a different definition of what constitutes a break than the accelerometer-derived measure, therefore absolute agreement would not be expected.

Paragraph 15 The characteristics (gender, education, work setting, age, BMI and accelerometer-derived breaks per sedentary hour) of those whose self-reported workplace sitting time varied by 10% or more of their accelerometer-derived workplace sedentary time were compared to those who did not (those who reported ≥10% more compared to those who did not; those who reported ≥10% less compared to those who did not). Differences were assessed by student's t-tests for

normally-distributed continuous variables (accelerometer-derived workplace breaks per sedentary hour), by Mann-Whitney U test for non-normally distributed continuous variables (age and BMI), and by chi-square for categorical variables (gender, education, work setting).

Results

*Paragraph 1*6 Characteristics of the *Stand Up Australia* participants who fulfilled the criteria for this study are presented in Table 1, overall and by work setting. Over half of the total sample was employed in office-based work. There were differences across the work settings, with call centre participants having a higher BMI and lower proportion of post secondary educational qualifications. Customer service participants had higher mean breaks per sedentary hour and lower mean workplace sedentary time than those in office-based and call centre settings.

INSERT TABLE 1 ABOUT HERE

Paragraph 17 **Total workplace sitting time:** At average levels of sitting and sedentary time (6.82hrs), self reported sitting time was 0.45hrs/day (95%CI: 0.23, 0.66) higher than accelerometer-derived sedentary time. The difference between the two measures was similar for office workers (0. 42hrs/day, 95%CI: 0.15, 0.68), but lower for call centre workers (0.16hrs/day, 95%CI: -0.26, 0.59) and higher for customer service workers (1.05hrs/day, 95%CI: 0.47, 1.63).

Paragraph 18 There were positive correlations between self-reported workplace sitting and accelerometer-derived workplace sedentary time in the total group (r_p=0.39 [95%CI: 0.22, 0.53]; r_s=0.29 [95%CI: 0.11, 0.44]), and in those employed in office-based (r_p=0.44 [95%CI: 0.24, 0.60]; r_s=0.34 [95%CI: 0.13, 0.52]) and call centre settings (r_p=0.27 [95%CI: -0.15, 0.61]; r_s=0.13 [95%CI: -0.29, 0.51]). There was no association between these two measures for those

employed in customer service (r_p=-0.06 [95%CI: -0.56, 0.47]; r_s=-0.02 [95%CI: -0.52, 0.50]), however, the confidence interval did not exclude a correlation of similar size to the office-based and call centre groups.

Paragraph 19 Figure 1 shows the Bland-Altman plot for self-reported workplace sitting and the accelerometer-derived workplace sedentary time for the total group. Linear regression showed a significant positive association between the difference in workplace sitting and sedentary time (sitting minus sedentary) and the average of these two measures (B=0.47, SE 0.12, p<0.001). Thus, the mean difference was estimated as -2.75 hours + 0.47 x average sitting/sedentary time. The limits of agreement were wide (mean difference +/-2.25hrs), though constant around the mean difference.

INSERT FIGURE 1 ABOUT HERE

Paragraph 20 **Breaks in sitting time:** There was a significant correlation between workplace self-reported breaks in sitting time and accelerometer-derived breaks per sedentary hour for the sample overall (r_s=0.26; 95%CI: 0.11, 0.44) and for those working in office-based (r_s=0.23; 95%CI: 0.02, 0.43) and call centre (r_s= 0.43; 95%CI: 0.04, 0.71) settings. Similar to the results for sitting time, there was no significant correlation between the self-report and objective measures of breaks for the participants employed in customer service (r_s=-0.05; 95%CI: -0.55, 0.48).

Paragraph 21 **Over- and under-reporters:** There was no difference between those who under-reported sitting time by more than 10% of their sedentary time (n=22) and those who did not over or under-report (n=51) in terms of the characteristics examined (gender, education, work

setting, age, BMI and accelerometer-derived breaks per sedentary hour). Similarly no difference was found for those who over-reported sitting time by more than 10% of their sedentary time (n=48) except for significantly (p=0.03) higher mean breaks per sedentary hour (8.44, SD 2.68) than those who did not over or under-report (7.23, SD 2.78).

Discussion

Paragraph 22 This study is the first to examine the validity of an interviewer-administered questionnaire measure of workplace sitting time and breaks in sitting time using objective criterion measures. The workplace sitting time question was significantly correlated with accelerometer-derived sedentary time during work hours. Self-reported breaks in sitting time had a slightly lower, but still significant, correlation with accelerometer-derived breaks per sedentary hour.

Paragraph 23 Validity of questionnaire measures of workplace sitting (15) and workplace sitting combined with standing (20) have been reported previously. However, these studies used an activity log as the criterion measure, so such findings are not comparable to the present results. Our findings are consistent with studies that have examined the criterion validity (accelerometer-derived sedentary time, <100 cpm) of the International Physical Activity Questionnaire (IPAQ) single item measure of sitting in the general population (r_s=0.07-0.61) (5, 21) and compare favourably with results for this question in a population recruited from workplaces (r_p=0.16) (8). Thus, while the correlations found in our study are modest, they appear to be at least as strong as those for the global sitting time measure in the IPAQ questionnaire.

Paragraph 24 The level of accuracy of workplace sitting time recorded by our questionnaire was close to the amount of sedentary time recorded during work hours (mean difference of

approximately half an hour at average levels of sitting time and sedentary time). This level of accuracy may be suitable for surveillance purposes. Similarly, the correlation between the two measures may be sufficient to rank people on the basis of their sitting time in large-scale workplace population studies. The limits of agreement, however, were wide, thus the measure may have less utility in studies that need a high level of accuracy at the individual level, for example, smaller-scale intervention studies. As the mean difference was not constant and the difference between the two measures was greater at higher mean levels of average sitting and sedentary time, therefore the measure may not be as accurate for those at the extremes of workplace sitting time.

Paragraph 25 Breaking up prolonged sitting time is a recent concern for health behavior and epidemiological studies. So far, such measures have been derived indirectly from accelerometers (10), by assessing transitions from low intensity movement (<100 cpm) to higher intensity movement. The self-reported breaks measure was significantly but not highly correlated with the accelerometer criterion measure. The comparison of a categorical with a continuous measure may have compromised the results. Furthermore, the definition of a break was slightly different for the self-report and accelerometer measures. The definition of a break in the questionnaire (standing up, or stretching or taking a short walk) would not have encompassed all possible breaks in sedentary time recorded by the accelerometer, or when the respondent did not consider the 'break' to have occurred during work time. For example, walking during lunch time would have been included by as a break by the accelerometer-derived measure, but possibly not by the self-report. Further development of this question, including different response sets and wording to achieve a better description of the target behavior, is required.

Paragraph 26 It is possible that a break in sitting time may be more easily recalled when it is less common or if there are workplace requirements around monitoring breaks, in the case of call centre workers (1), which makes this event more memorable. Additionally, more frequent transitions from sitting to standing could make recalling sitting time and breaks in sitting time more difficult. If true, then self-report measures of sitting time and breaks in sitting may perform better in populations who are more at risk - those who spend greater periods in unbroken sitting.

Paragraph 27 The primary strength of this paper is that an objective measure of movement was used as the criterion. However, accelerometers cannot be considered a true 'gold standard' measure of sitting time since they do not detect body position. Periods considered sedentary (<100 cpm) may include some time spent standing still resulting in overestimation of sedentary time, although periods considered non-sedentary may also have included time spent sitting. Thus, the amount of absolute difference between self-report and accelerometer may have been under or over-estimated. The utility of the 100 cpm cut-point has only been established in limited population groups (16) and further research is required to determine the cut point that best maps to people's sitting. This level of activity has been used in other papers examining the criterion validity of sitting time questionnaires (5, 9, 21) and therefore provides some consistency to compare results.

Paragraph 28 A further limitation is that our study used a convenience sample; thus, the sample is not population representative. Nevertheless, we had minimal evidence of bias in our recruitment, with little difference between study participants and non-participants in terms of the characteristics we could examine (age and gender). Importantly, participants came from three varied work settings including typically high sitting environments (call centre) in which

measures of sitting time may be employed for surveillance. Findings may not be representative of less sedentary workplaces, as suggested by the lower correlations within customer service employees, although small numbers in this group resulting in wide confidence intervals mean we cannot draw definitive conclusions here. Additionally as this questionnaire was interviewer-administered, results may not be valid if it is self-completed. Further examination of the utility of self-report measures such as ours, both interviewer-administered and self-completed, in workplaces with more varied patterns of sitting is recommended.

Conclusions

Paragraph 29 The interviewer-administered measure of workplace sitting time that we examined has properties which may be acceptable for use in large population based studies. However, the wide limits of agreement suggest caution in using the measure when more accurate measures of sitting time at the individual level are required. The measure of workplace breaks in sitting time needs further refinement for use in future health behavior and epidemiological studies.

ACKNOWLEGEMENTS

Paragraph 30 Clark is supported by an Australian Post Graduate Award Scholarship and Queensland Health funding. Healy is supported by a NHMRC (#569861) / National Heart Foundation of Australia (PH 08B 3905) Postdoctoral Fellowship. Dunstan is supported by a Victorian Health Promotion Foundation Public Health Research Fellowship. Winkler and Owen are supported by a Queensland Health Core Research Infrastructure grant and by NHMRC Program Grant funding (#301200). Gardiner is supported by a National Heart Foundation of Australia (#PP 06B 2889) Postgraduate Scholarship.

The results of this study do not constitute an endorsement by the American College of Sports Medicine.

CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

Table 1: Characteristics of the overall sample, and of the participating workers from office, call centre and customer service work settings

	Total	Office	Call Centre	Customer Service
N	121	82	24	15
Demographics				
Gender: Women % (n)	60% (73)	66% (54)	42% (10)	60% (9)
Age in years, median (interquartile range)	34.9 (28.5, 46.0)	35.5 (30.6, 47.3)	29.2 (25.0, 40.1)	39.5 (27.6, 53.5)
BMI (kg/m^2), median (interquartile range)	25.7 (23.5, 29.1)	25.5 (23.7, 28.9)	27.8 (22.9, 35.8)	24.8 (23.1, 28.3)
Education: Post high school education % (n)	74% (89)	81% (66)	54% (13)	67% (10)
Self-reported meeting physical activity guidelines % (n)*	7.4% (9)	8.5% (7)	4.2% (1)	6.7% (1)
Married % (n)	69% (83)	71% (58)	63% (15)	67% (10)
Self-reported work hours/day (recorded in activity log)	8.69 (0.97)	8.96 (0.83)	8.25 (0.51)	7.96 (0.84)
Self-reported sitting:				

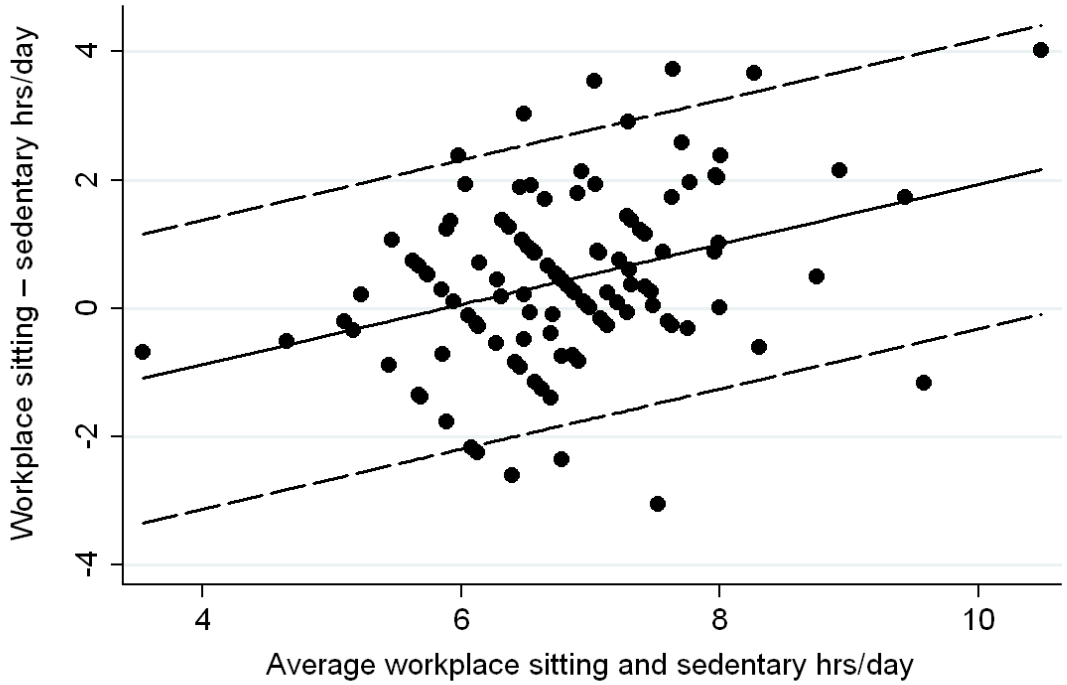

Figure 1: Bland Altman Plot for workplace sitting time in 121 participants. The y axis is the difference between questionnaire-measured workplace sitting time and accelerometer-derived sedentary time in hrs/day. The x axis is the average of workplace sitting time and sedentary time in hrs/day. The solid line represents the mean difference between the two measures (B=0.47, SE+0.12, $p<0.001$) with the mean difference being -2.75 + 0.47*average, and the dashed lines are the limits of agreement (mean difference +/- 2.25hrs).

APPENDIX

Questions for work sitting and breaks in sitting time:

The questions used in the *Stand Up Australia* study to examine work-related sitting are as follows:

Sitting for work

Please estimate the total time during the last week that you spent sitting down as part of your job while at work or working from home?

Work days (In hours and / or minutes – fill in squares on answer sheet)

☐☐ hours ☐☐ minutes

Breaks in sitting time

How many breaks from sitting (such as standing up, or stretching or taking a short walk) during one hour of sitting would you typically take at work?

5 or more 4 3 2 1 0

References:

1. ACTU. Call centre minimum standards code [Internet].Australian Council of Trade Unions; [cited 13 September 2010] Available from: www.actu.org.au/public/papers/minstandscode/minstandscode.rtf
2. Bland JM, and Altman GA. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet.* 1986:307-311.
3. Brown R, and Richmond S. An update on the analysis of agreement for orthodontic indices. *Eur J Orthod.* 2005;27(3):286-91.
4. Carnethon M, Whitsel LP, Franklin BA, et al. Worksite wellness programs for cardiovascular disease prevention: a policy statement from the American Heart Association. *Circulation.* 2009;120(17):1725-41.
5. Craig CL, Marshall AL, Sjostrom M, et al. International physical activity questionnaire: 12 country reliability and validity. *Medicine & Science in Sports & Exercise.* 2003;35:1381-95.
6. Department of Health and Human Services. *Essential elements of effective workplace programs and policies for improving worker health and wellbeing*: Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health; 2008. DHHS (NIOSH) Publication No. 2010-125. p1-4
7. Dunstan DW, Barr ELM, Healy GN, et al. Television viewing time and mortality: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Circulation.* 2010;121:384-391.

8. Ekelund U, Sepp H, Brage S, et al. Criterion-related validity of the last 7-day, short form of the International Physical Activity Questionnaire in Swedish adults. *Public Health Nutrition.* 2006;9(2):258-65.

9. Fjeldsoe BS, Marshall AL, and Miller YD. Measurement properties of the Australian Women's Activity Survey. *Med Sci Sports Exerc.* 2009;41(5):1020-33.

10. Healy GN, Dunstan DW, Salmon J, et al. Breaks in sedentary time: beneficial associations with metabolic risk. *Diabetes Care.* 2008;31:661-666.

11. Healy GN, Dunstan DW, Salmon J, Shaw JE, Zimmet PZ, and Owen N. Television time and continuous metabolic risk in physically active adults. *Medicine and Science in Sports and Exercise.* 2008;40(4):639-645.

12. Healy GN, Matthews CE, Dunstan DW, Winkler EA, and Owen N. Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003-06. *Eur Heart J.* 2011; In Press.

13. Hu FB, Leitzmann MF, Stampfer MJ, Colditz GA, Willett WC, and Rimm EB. Physical activity and television watching in relation to risk for type 2 diabetes mellitus in men. *Archives of Internal Medicine.* 2001;161(12):1542-8.

14. Hu FB, Li TY, Colditz GA, Willett WC, and Manson JE. Television watching and other sedentary behaviors in relation to risk of obesity and type 2 diabetes mellitus in women. *Journal of American Medical Association.* 2003;289:1785-91.

15. Marshall AL, Miller YD, Burton NW, and Brown WJ. Measuring total and domain-specific sitting: a study of reliability and validity. *Medicine & Science in Sports & Exercise.* 2010;42(6):1094-1102.

16. Matthews CE, Chen KY, Freedson PS, et al. Amount of time spent in sedentary behaviors in the United States, 2003-2004. *American Journal of Epidemiology.* 2008;167(7):875-81.

17. McCormack G, Giles-Corti B, and Milligan R. The test-retest reliability of habitual incidental physical activity. *Australian and New Zealand Journal of Public Health.* 2003;27(4):428-433.

18. Miller R, and Brown W. Steps and sitting in a working population. *International Journal of Behavioral Medicine.* 2004;11(4):219-24.

19. National Preventative Health Taskforce. *Australia: The Healthiest Country by 2020 – National Preventative Health Strategy – the roadmap for action*: Commonwealth of Australia; 2009. p112

20. Reis JP, Dubose KD, Ainsworth BE, Macera CA, and Yore MM. Reliability and validity of the occupational physical activity questionnaire. *Medicine & Science in Sports & Exercise.* 2005;37(12):2075-83.

21. Rosenberg DE, Bull FC, Marshall AL, Sallis JF, and Bauman AE. Assessment of sedentary behavior with the International Physical Activity Questionnaire. *Journal of Physical Activity and Health.* 2008;5(Supplement 1):s30-s44.

22. Salmon J, Owen N, Crawford D, Bauman A, and Sallis JF. Physical activity and sedentary behavior: a population-based study of barriers, enjoyment, and preference. *Health Psychology.* 2003;22(2):178-188.

23. van Uffelen JGZ, Wong J, Chau JY, et al. Occupational sitting and health risks: a systematic review. *American Journal of Preventive Medicine.* 2010;39(4):379-388.

24. Zhang M, Xie X, Lee AH, and Binns CW. Sedentary behaviors and epithelial cancer risk. *Cancer Causes & Control.* 2004;15:83-89.