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Office Sitting Made Less Sedentary – A Future-forward Approach to Reducing Physical Inactivity at Work

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ABSTRACT

Excessive sitting is detrimentally associated with major lifestyle diseases. Attempts at intervening the prolonged sitting time at work offer possibilities for a healthier lifestyle. The aim of the study was to evaluate the impact of using a seat-cycle (S-C) compared to the office-chair (O-C) in reducing prolonged sitting in the office. Twenty-one (mean age = 48±12.4 years) office workers (10 men and 11 women; mean BMI = 24.1±4.6 kg/m²) volunteered to participate in an 11-week crossover design study. Participants were randomly assigned into two groups- each started with different conditions: the office-chair (O-C) or the seat-cycle (S-C) intervention for 4 weeks with a 2-week 'washout' period in-between before switching over. Self-reported sleep quality, lower back pain, daytime sleepiness and several anthropometric measurements were obtained under the two conditions. Participants spent on average 5.79±1.51 hrs sitting in the office, and used the seat-cycle for an average of 22.8 minutes daily at work. Significant improvements ($p<0.05$) were noted in a pre-to-post setting for resting systolic blood pressure (124.9±12.57 mmHg vs 120.5±13.56 mmHg); sleepiness ratings between 1300–1400 hrs (1.91±0.71 vs 1.56±0.57); lower back pain score (0.95±1.02 vs 0.57±0.68) and sleep quality (4.81±2.16 vs 3.38±2.04) after the S-C intervention. The use of the S-C provides desk-bound workers a potential way to interrupt prolonged sitting at work and further research is recommended to support such interventions at the workplace.

***Key words:** sedentary office workers, prolonged sitting, workplace intervention.*

Introduction

Employees report spending a majority of office time sitting and are at greater risk of developing sedentary lifestyles (Miller & Brown, 2004). Sedentary behaviours are defined by posture (sitting or lying) and low energy expenditure (1.0–1.5 METs), apart from sleeping (Owen, Healy, Matthews, & Dunstan, 2010). Prolonged sitting is negatively associated with musculoskeletal symptoms and risks of detrimental cardio-metabolic health, especially when accumulated in uninterrupted bouts (Neuhaus, Healy, Dunstan, Owen, & Eakin, 2014). Population-based accelerometer studies in North America show that only 1–5% of the waking day of an adult, who sleeps an average of eight hours, is spent in moderate-to-vigorous physical activity (MVPA) with the remaining time spent in sedentary activities (Hamilton, Healy, Dunstan, Zderic, & Owen, 2008). The situation in Singapore is dire as a global survey of working hours in 2011 among developed countries showed that Singaporean workers worked the longest hours in the world (AsiaOne, 2013). The Health Promotion Board (HPB) of Singapore recommends 150 minutes of aerobic activity at moderate intensity spread throughout the week for good health (Health Promotion Board, 2011b) and it was reported that the proportion of adults aged 18 to 69 who engaged in regular leisure-time exercise only rose from 17% to 19% in 2004 to 2010 (Mintistry Of Health, 2010). Singapore's Minister for Culture, Community and Youth cited the Sports Participation Survey for 2013 and 2014 that showed the nation's overall participation rate in sports has risen to more than 60%, up from 42% in 2011 (AsiaOne, 2015). While it appears that more adult Singaporeans are taking part in physical activities, a recent finding from HPB revealed that there are 1.7 million of Singaporeans already at risk of obesity-related diseases (Health Promotion Board, 2014). In addition to the increased risk of these lifestyle-related diseases, the lack of physical activity (PA) is suggested to be associated with poorer sleep quality amongst adults (Wennman et al., 2014), and an increase in lower back pain (Hurwitz, Morgenstern, & Chiao, 2005).

According to Singapore's National Health Survey 2010, 10.8% of the adults aged between 18 and 69 were classified as obese compared to 6.9% in 2004 (Ministry Of Health, 2010). The prevalence of obesity was highest in the 30–39 years age group at 12.3% with this demographic comprising mainly of working adults. Sedentariness at work among adults over time is linked to an increased risk of obesity (McCrady & Levine, 2009) and poor metabolic health. Furthermore, some studies show that among sedentary male adults, those who sat for more than four hours daily are more susceptible to lifestyle chronic diseases (George, Rosenkranz, & Kolt, 2013). HPB Singapore has been encouraging companies to introduce Workplace Health Promotion (WHP) programmes such as physical activities for workers to be more physically active and there is an increased prevalence of these programmes in the past decade with 45.1% of private companies adopting programmes in 2003, rising to 56.3% in 2010 (Health Promotion Board, 2011a). Decreasing time spent being sedentary at work and encouraging office workers to adopt healthy lifestyles form an important approach at addressing adult obesity in Singapore.

Novel workstation modifications (such as treadmill desks), which help to break up prolonged sitting time such as the use of standing desks (Alkhajah et al., 2012) have shown positive results and potential benefits in the long term. However,

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substituting prolonged sitting with standing all day is reported to give rise to other health problems such as musculoskeletal pain and venous insufficiency in the legs (McCulloch, 2002). Also treadmill desks may be impractical for most office workers due to its size and cost. At present, apparently no research has examined the use of a seat-cycle (*S-C*) to replace the normal office-chairs (*O-C*) to break up sedentary sitting time at work. Seat cycles are a potentially feasible option to reduce sedentariness at work without a major disruption of office work practices. The aim of the present study was to investigate the effectiveness of using a seat cycle in replacement of the office chair for improving health outcomes of office employees in a worksite in Singapore.

Methods

Participants

Twenty-one office staff (10 males and 11 females; mean age = 48±12.4 years; mean BMI = 24.1±4.6 kg/m²) from an educational institution in Singapore volunteered to participate in the study. A briefing session was conducted to inform participants about the study procedures. A Physical Activity Readiness Questionnaire (Singapore, 2011) and consent forms were completed and signed prior to the commencement of the study. A familiarization session on the use of the seat-cycle was also accomplished. Participants were excluded if they were pregnant or had any medical conditions. The study was approved and cleared by the university board for ethics involving the use of human subjects (IRB-2013-03-005). The physical characteristics of the participants are summarized in Table 1.

Seat-cycle

The seat-cycle chair measures 57cm x 39cm x 76cm with attached pedals with low resistance. Data for the cross-over design study were collected between May and September, 2014.

Protocol

An 11-week study consisted of a 1 week pre-intervention phase followed by two, 4-week experimental phases in a randomized, crossover study design, involving the use of the *O-C* and the *S-C*, respectively. A 2-week washout period separated the experimental phases. Each participant went through both intervention phases and their results were compared. A schematic representation of the study is shown in Figure 1.

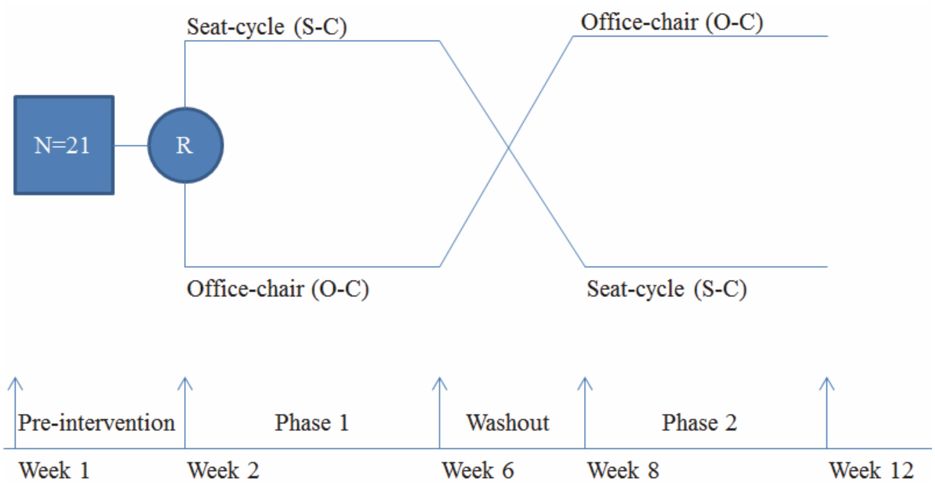

Figure 1. Schematic representation of the study

Twenty-one participants using a cross-over design were monitored on the following:

Participants completed hourly Stanford Sleepiness Scale (Hoddes, Zarcone, Smythe, Phillips, & Dement, 1973) (SSS) rating when in the office (0900–1700 hours) daily throughout the study. The Pittsburgh Sleep Quality Index (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) (PSQI) questionnaire and Roland-Morris Disability Questionnaire (Roland & Fairbank, 2000) (RDQ) were administered at the end of each phase.

Week 1 (Monday-Friday): *Pre-intervention*- Participants were familiarised to complete the SSS on the hour while at work in the office and the PSQI and RDQ questionnaires at the end of the week.

Week 2-6 (Monday-Friday): Group 1- *(S-C phase):* The seat-cycle was provided and the workstations were modified such that the computer screen was at eye level whilst seated for each participant. Participants were instructed to cycle at a self-selected cadence so as to minimise disruption to their work.

Group 2- *(O-C phase)*: Participants continued with the normal work conditions with a desk and office chair.

Week 6-8 (Monday-Friday): *Washout period*- The seat-cycles were removed from Group 1. Both groups continued with the normal work condition of a desk and office chair set up.

Week 8-12 (Monday-Friday): Group 1 continued with the normal work condition of a desk and office chairs *(O-C phase).* Group 2 had the seat-cycle set up at the workstation *(S-C phase).*

Measurements

An accelerometer (Actitrainer 3 axis; Actigraph, Pensacola, USA) was attached to one of the pedals of the seat cycle to measure the cycling time of each participant daily throughout the period of monitoring. ActiLife version 4.5.0 (Actigraph) was used to extract the raw data. The data were exported to Microsoft Excel 2010 and further processed to compute the total daily amalgamated cycle time between 0900 and 1700 hours. Body stature, body mass, resting blood pressure and heart rate of the participants in the pre-and post-intervention conditions, were measured according to the methods described in *Exercise Physiology Laboratory Manual 7th Ed* (Beam & Adams, 2014).

Questionnaires

i) Stanford Sleepiness Scale (SSS)
The SSS is a self-rating 7-point scale used to quantify perceived changes in sleepiness for any time period of the day or night (Hoddes et al., 1973). The validated scale has been used in studies to collect subjective measures of workers' sleepiness levels (Kato, Shimada, & Hayashi, 2012). In the present study, participants rated their level of sleepiness on a scale of 1 (active, vital, alert or wide awake) to 7 (Sleep onset soon and having dream-like thoughts) on the hour when they were physically present in the office.

ii) Pittsburgh Sleep Quality Index (PSQI)
The PSQI questionnaire is a survey-type instrument used to assess sleep quality during the previous month (Buysse et al., 1989). It consists of 19 self-rated questions and five questions answered by the bed partner or roommate. On the self-rated items, respondents indicate the amount of sleep they get and rate the extent to which various factors interfered with their sleep on a four-point Likert-type scale (0 = not at all, 3 = three or more times per week) (Beaudreau et al., 2012). The scoring was calculated as a numeric index using a template in accordance to the published work of Buysse et al. (1989). A final score of more than 5 indicated poor sleep quality.

iii) Roland-Morris Disability Questionnaire (RDQ)
The RDQ is a health status questionnaire completed by patients with lower back pain to access their physical disabilities (Roland & Fairbank, 2000). Participants completing the RDQ were instructed to check mark the statements that most applied to them. The RDQ has been used in studies to access the lower back pain of office workers (del Pozo-Cruz et al., 2012). In the present study, the RDQ was used to assess short-term changes in lower back pain in response to the intervention. The higher numerical scores indicate a higher severity of the lower back pain.

Statistical analyses

Descriptive statistics of key variables were described and pre-to-post measurements were analysed by paired-sample t tests using SPSS version 21 and statistical significance was defined as $P<0.05$. The effect sizes (ES) for variables which had significant differences between pre to post measurements were calculated using Cohen's d, where 0.2 is indicative of a small effect, 0.5 a medium and 0.8 a large effect (Cohen, 1992). Pearson product-moment correlation coefficient (r) was used to measure linear correlation between cycling time on the seat-cycle and the significant pre-post differences. Post-hoc statistical power of the group analyses were calculated using G*Power 3.1.

Results

The physical characteristics of the participants are summarised in Table 1.

Table 1. Physical characteristics of participants

Variables	Means ± SD
N	21
Age (years)	48 ± 12.4
Height (m)	1.65 ± 0.08
Body mass (kg)	65.2 ± 11.1
BMI (kg/m²)	24.1 ± 4.6
Waist to Hip ratio	0.83 ± 0.08

RDQ scores, PSQI, anthropometric and physiological measurements obtained during the pre and post of *O-C* and *S-C phases* were analysed. These data are summarised in Table 2.

Table 2. Pre and post measurements of participants for the Office-chair (*O-C*) and Seat-cycle (*S-C*) phases

	Phase	Pre	Post
Resting Heart Rate (bpm)	*O-C*	70.36±10.66	71.93±13.72
	S-C	69.14±10.03	67.48±11.09
Resting Systolic Blood Pressure (mmHg)	*O-C*	120.35±12.69	120.64±13.19
	S-C	124.9±12.57	120.53±13.56*
Resting Diastolic Blood Pressure (mmHg)	*O-C*	74.9±9.63	73.07±10.41
	S-C	76.67±9.41	74.35±11.06
Body mass (kg)	*O-C*	65.36±11.00	65.14±10.76
	S-C	65.09±10.92	65.42±10.80
Waist-Hip Ratio	*O-C*	0.84±0.08	0.81±0.09
	S-C	0.80±0.09	0.83±0.08
Body Mass Index	*O-C*	24.13±4.58	24.33±4.54
	S-C	24.33±4.60	24.14±4.54
Roland-Morris Disability Questionnaire (RDQ) scores	*O-C*	0.9±1	0.81±0.98
	S-C	0.95±1.02	0.57±0.68*
Pittsburgh Sleep Quality Index (PSQI)	*O-C*	4.29±2.15	4.81±2.5
	S-C	4.81±2.16	3.38±2.04*

Data were shown as Mean ± SD
**pre-to-post differences are significant at p<0.05*

There were significant improvements ($p<0.05$) in resting systolic blood pressure (124.9±12.57 mm/Hg to 120.53±13.56 mmHg, ES = 0.33), RDQ score (0.95±1.02 to 0.57±0.68, ES = 0.44) and PSQI (4.81±2.16 to 3.38±2.04, ES = 0.68) between the pre and post conditions of the *S-C phase*. Mean hourly SSS ratings from 0900–1700 hours during the *O-C* and *S-C phases* were 1.59±0.49 and 1.48±0.57, respectively. The average hourly levels of sleepiness reported during the *O-C* and *S-C phases* are shown in Figure 2. The differences in the average hourly sleepiness ratings during the two phases were greatest between 1300–1600 hours (i.e. 1.74±0.57 during the *O-C* and 1.52±0.52 during the *S-C phases)*. Significant differences in the average sleepiness ratings between the two conditions were observed at 1300–1400 hours (1.91±0.71 to 1.56±0.57, $p<0.05$, ES = 0.55).

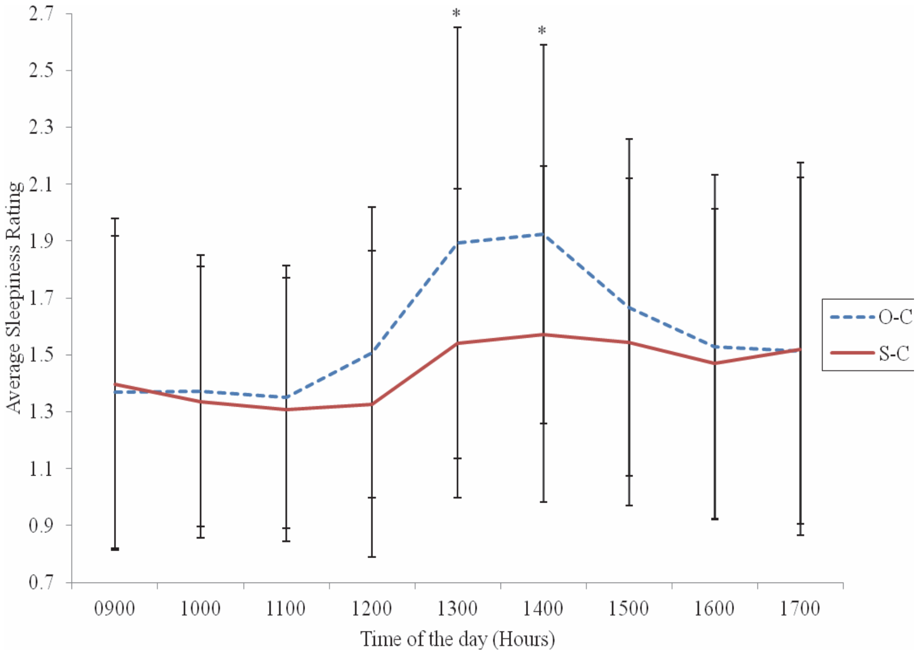

Figure 2. Average daily hourly Stanford Sleepiness Scale ratings for each phase

Legend: * Significant differences ($p<0.05$) in pre-post sleepiness ratings; O-C: Office-chair; S-C: Seat-cycle; Sleepiness ratings- higher scores indicate higher levels of sleepiness.

Data derived from the hourly SSS ratings throughout the study showed that participants spent a daily average of 5.79±1.51 hours at work in the office. During the *S-C phase*, participants spent an average of 5.65±1.97 hours presumably, sitting in the office, of which, an average of 22.8 minutes was spent cycling on the seat cycle on a daily basis. As such, time spent cycling on the seat cycle was about 7% of the total monitored time, with the remaining 93% of the monitored time spent presumably sitting during the *S-C phase*.

There were no significant correlations ($p>0.05$) found between the time spent cycling on the seat-cycle and significant pre-to-post differences of the variables. However, there was a significant correlation (r = -0.449; $p<0.05$) between the pre-to-post difference in the PSQI and SSS ratings at 1400 hours.

Discussion

Results of the present study showed that using a seat cycle at work is beneficial to the health of office workers in terms of (i) lower resting systolic blood pressure, (ii) lower back pain scores, (iii) better sleep quality and (iv) lower sleepiness ratings at 1400 hours. These data are meaningful as the effect sizes for the differences in variables from the pre-to-post conditions are in the moderate range (i.e. ES = 0.33 ~ 0.68). With modern advancements and dependence on technology, manual labour has been greatly reduced, causing a negative impact on health. The office workers spent on average, a large amount of time daily (5.65±1.97 hours) presumably sitting in the office on regular 8-hour (0900–1700 hours) workdays during the *S-C phase*. Despite spending only about 7% of the total office time cycling on the seat-cycle, significant improvements were observed in their resting systolic blood pressure, sleepiness ratings during 1300–1400 hours, lower back pain score and sleep quality index. Studies show that there is usually a post-lunch spike in sleepiness level (Bes, Jobert, & Schulz, 2009) which could explain the sudden rise in the average SSS ratings between 1300–1600 hours during the *O-C phase*. These ratings decreased significantly during 1300–1400 hours of the *S-C phase* suggesting a possible positive impact of cycling on the seat-cycle in improving alertness at work.

Prolonged sitting leads to detrimental health effects such as increased risks for venous thrombosis and it is suggested that short, frequent light-intensity walking breaks were effective at reducing these risk (Howard et al., 2013). Results of the present study suggest that using a seat cycle to break up sedentary office time was effective in terms of improving alertness, lower back pain conditions and sleep quality. Sedentary office jobs can also lead to much lower energy expenditure of 2000 kcal daily less than active jobs (Koepp et al., 2013). Unpublished work from our study showed significant increases in MET values (up to 2.4 times of baseline values) when cycling and while reading on the seat-cycle in an office setting which suggested an increase in energy expenditure (Byrne, Hills, Hunter, Weinsier, & Schutz, 2005). This demonstrated the usefulness of using a seat cycle in place of an office chair in increasing PA levels at work.

Occupational sedentariness is associated with several health complications and modifying the workplace for successful solutions requires multiple innovative approaches (Koepp et al., 2013). In the present study, participants spent about 7% of their office time cycling on the seat-cycle which showed that a single change of the work environment (i.e. introduction of a seat cycle) may not be substantial in influencing a significant change in sitting behaviour for office workers. A pilot study conducted at a Tasmanian workplace showed that employees were five times more likely to complete a movement break every hour of the work day when passive computer prompts were used as compared to active prompts (Cooley & Pedersen, 2013). Researchers in the USA reported increased usage of stairs through an interactive activity of allowing employees to incorporate their own history and thoughts into paintings which in turn helped to decorate the stairwells (Swenson & Siegel, 2013). The existing literature on reducing prolonged sitting behaviour suggests a combination of interventions or activities might be required to contribute to the sustainability of reducing prolonged sitting at work. Such multipronged strategies to reduce prolonged sitting at work should be explored in Singapore for future research.

Limitations of the present study

The duration of the present study was relatively short. Koepp et al. (2013) reported that participants in an intervention study adapted to the new treadmill desks only after the first three months, hence the 4-week intervention in the present study may not be sufficient long to effect a substantial change in behaviour. We also acknowledge the small sample size of the present study, which is reliant on volunteers. Nonetheless, the post-hoc statistical power analysis of the results yielded power of 54 to 60% for resting systolic blood pressure, RDQ scores and SSS ratings at 1300–1400 hours; and a high power of 82% for sleep quality. Throughout the study, we did not objectively measure the PA of the participants for the periods when participants were not using the seat-cycle. Therefore in the present study, we could not account for the amount of physical activity engaged during the ‘non-use time’ of the seat-cycle and hence unable to determine for certain whether the results were caused directly by the intervention or were due to any ‘spill-over’ effects of the physical activities engaged when not using the seat-cycle.

Conclusion

The seat-cycle is a piece of equipment that can potentially replace the normal office chair as a mean to increase daily PA at work by cutting down on long periods of sitting in the office and is effective in effecting various health outcomes- improved alertness at work, reduced lower back pain and disability, better sleep quality, and an improved resting blood pressure. Future research using a multipronged approach at intervention to reduce prolonged sitting at work to affirm the practicality and health benefits of exercising and working in the office at the same time are highly recommended.

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