A PILOT STUDY OF SHORT-TERM EFFECTS OF NON-SEDENTARY BEHAVIOUR ON MOOD CHANGES

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Abstract: Sedentary behaviour is considered to be a major factor impacting a number of health outcomes while use of technology in the workplace is increasingly contributing to the amount of sedentary time. Even if guidelines on the amount of physical activity are followed outside of workplace, sedentary work style still has a deleterious impact on health. There have been a number of studies that investigated the impact of sedentary behaviour on general health while no study has reported investigation of effects of sedentary behaviour on mood changes. The aim of this pilot study, which included 14 knowledge workers, was to objectively measure sedentary time using accelerometers and investigate correlation with the self-reported mood changes in short term. The results show that sedentary behaviour has negative effects on the mood even over a short period of one day. Although a pilot study, this is the first study to examine short term psychological implications of sedentary behaviour. Randomised controlled experiments are needed to further clarify these findings.

1. INTRODUCTION

Conveniences of modern life in developed countries are having an adverse effect on health. This is particularly manifested through decreased physical activity, where people spend significant amount of time in sedentary activities. Physical inactivity leads to a number of health outcomes and various media campaigns are designed to encourage increase in physical activity levels and promote healthy lifestyle. However, a general increase in physical activities outside work hours is not sufficient to compensate for deleterious effects of sedentary time in workplaces. Sedentary work style has adverse health risks, where negative effects on health occur even if people follow the guidelines on physical activity outside of the workplace [3, 19]. As a number of studies have shown [1, 3, 5, 9, 10, 11, 19] prolonged sitting leads to an array of health complications, including diabetes, high blood pressure and obesity.

Office workers typically adhere to a work style that requires sitting for prolonged periods of time. Therefore, monitoring sedentary patterns in workplace provides a good basis for polices that encourage healthy work style and minimize the time spent in sedentary activities. In addition to physical health effects, sedentary behaviour also has a negative effect on mental health. The closest study to our work has linked prolonged sitting time with mental health disorders [1], however, no study has been reported that has investigated correlation between sedentary patterns and mood changes.

The aim of our pilot study was to investigate how sedentary work style affects office workers' subjectively reported mood. Measuring mood changes is important when considering mood shifts are linked to serious diseases, such as depression, bi-polar disease but also cost economies an average of $44 billion per year in Lost Productive Time (LPT) [2].

In our study we used well-established technologies to monitor sitting time, namely mobile phones with embedded accelerometers. Using mobile phones as a sensing device not only allows for precise measurements of physical activities and sedentary periods (thus overcoming recall biases and floor effects [4]), but also provides an unobtrusive monitoring platform that does not interfere with the typical office workers' routines. In this manner, we were able to measure precisely sedentary behaviour at workplace and correlate the findings with the reported mood changes. The study described in this paper is the first to have investigated this issue and we hope it will motivate further research in the implications of sedentary behaviour on psychological response.

2. BACKGROUND AND RELATED WORK

Sedentary behaviour (from the Latin "sedere" meaning "sitting") refers to the category of behaviours for which the energy expenditure is low, including prolonged sitting periods at work, home, in car, bus, and in leisure time [3]. Sedentary behaviour, characterized by the SITT formula (Sedentary behaviour frequency, Intensity, Time and Type), is often associated with adverse health outcomes. Emerging studies suggest that independently and qualitatively different from a lack of moderate or intense physical activity, sedentary behaviour has effects on human metabolism, physical function and health outcomes and therefore it should be considered as a separate and unique phenomenon [3]. Even if one meets physical activity guidelines, sitting for prolonged periods increases the risks for obesity, metabolic syndrome, type 2 diabetes and cardiovascular disease [3, 5].

Previous research initiatives have relied on self-reporting methods to acquire information about activities that correspond to sitting routines. Self-reporting of physical activity have a number of drawbacks including floor effects and recall bias [4] while continuous monitoring over long periods of time may disturb habitual physical activity [6]. On the other hand, accelerometers can provide recognition of physical activities such as sitting, running, standing [7, 8] and in addition record further details such as duration, frequency and intensity of movements. Accelerometers have become critical in investigation of sedentary habits that are difficult to recall with the questionnaire method. With the advancement of technology, accelerometers have been used to capture sedentary patterns in an objective manner, thus overcoming the drawbacks of self-reporting. Usage of accelerometers allowed significant results in establishing the influence of sedentary behaviour on metabolism [9], vascular health [9] and bone mineral content [10]. Moreover, recent studies link sedentary lifestyle and obesity [11], cancer [12] and psychosocial health [13]. Sanchez-Villegas et al. [1] found that the risk of mental disorders was 31% higher for prolonged patterns of sitting in front of a computer or a TV, comparing subjects that spend more than 42h/week in front of a TV with those watching less than 10.5h/week. The extensive literature survey on the implications of sedentary lifestyle, provided by Tremblay et al. [3], concludes that there is a need to understand the factors of sedentary behaviour and to implement interventions to reduce population-wide levels of sedentary behaviour, shifting some proportion of time from sitting to various types of physical activity. The authors [3] suggest that this should be done empirically. By conducting an empirical study that investigates non-sitting periods during working time, we have studied the correlation between sedentary patterns at workplace and office workers' mood changes, which may form the basis for strategies to reduce prolonged sitting periods. Our work is the first to investigate the influence of sedentary behaviour on mood changes, opening up a research avenue to explore psychological effects of increasing prevalence of sedentary habits.

3. MOTIVATION

Examining the influence of sedentary behaviour on psychological responses of an individual stemmed from an immense research body that was focused on physiological implications of sedentary lifestyle [1, 3, 5, 9, 10, 11, 19]. The postulates of physiological psychology that interrelate physiological and psychological processes [31] prompted us to investigate whether prolonged periods of sitting may also cause psychological responses.

The current literature provides number of directions for the possible correlation between sedentary behaviour and psychological reactions:

- Effects of sedentary behavior on insulin sensitivity are extensively examined [9, 23, 24] indicating that even single portions of prolonged inactivity, such as days or weeks, decrease insulin sensitivity in normal subjects. On the other hand, recent studies have shown that insulin affects the secretion of serotonin in the brain. It also impacts

memory and mood [25] and causes mood changes [26], while even postpartum mood disorders were attributed to decreased insulin levels [23].

- The lipid metabolism and prolonged periods of inactivity are related according to the animal studies [28] which indicated the correlation even for shorter periods of inactivity such as 4 hours or several days. Wells et al. [27] claim that the presence of lipids can induce sleepiness and mood changes.
- The effects of prolonged sitting on sympathetic activity are demonstrated in [24]. On the other hand, close relationship between anxiety and sympathetic nervous system activity is well-established [27] while there were also attempts to correlate sympathetic activity with mood states [29] and diurnal variations [30].

However, it would be inappropriate to claim correlation between sedentary behaviour and the mood based solely on the physiological parameters as an underlying factor. Rather, this provided us the motivation to examine the effects of sedentary behaviour on psychological responses independently from physiological parameters.

4. STUDY DESIGN

4.1 Mood assessment

The mood may depend on a number of different factors, such as circadian rhythms [14], type of environment [15], quality of sleep [16], state of health, private problems or other factors incomprehensible not only to direct measurement but also difficult for an individual to identify. Therefore, it may be impossible to consider all the factors that influence the mood and provide the ultimate conclusion about the exact cause of one's state of mood. For this reason, our approach is to follow relative changes of mood rather than focus on an absolute mood state. This is because we assume that the interval between two mood assessments of a couple of hours (in our design) is not sufficient for a significant change in "background" factors. These factors, such as private problems for example, are likely to be constantly present during relatively longer periods of time while, the events within that period have pre-dominant influence on relative changes of mood. In our mood study we aim to capture sedentary patterns during the day that correlate with similar responses in individuals' mood. Our method for assessing mood fluctuations during the day is based on EMA (Ecologically Momentary Assessment) approach in order to compare retrospective and momentary mood data [17]. The EMA approach, which involves asking participants to report their psychological state multiple times a day, reduces the critical issue of retrospective recall of extended time intervals. The retrospective recall issue is related to cognitive and emotive limitations that bias the recall of autobiographical memory [17] influencing subject's report by most salient events during the recall interval. The questionnaire we used was derived from a well-established scale for mood study – the Profile of Mood States (POMS) scale that consists of 65 items in its standard version. However, long and repeated mood questionnaires become a burden on subjects, therefore a short version of the POMS scale was used. We derived 8 adjectives from the POMS scale, namely cheerful, sad, tensed, fatigued, energetic, relaxed, annoyed and friendly that were rated on 5-point scale (1-not at all, 2- a little, 3-moderately, 4 quite a bit, 5- extremely). The scores were summed across the items related to positive and negative expression in order to generate a single score for each mood report. The difference of that score (between two sequential questionnaires) was taken as a measure of relative change of subject's mood. The questionnaires were administered three times a day, scheduled to best fit with the work routines, while also allowing the user to manually invoke the questionnaire. Typically, the questionnaires were answered in the morning, after lunch and at the end of working day.

4.2 Sedentary time

Accelerometers provide an important research tool able to reliably measure and classify a number of physical activities, including walking, jogging, sitting, standing [7], and more complex activities such as estimation of metabolic energy expenditure, sit-to stand transfers, and assessment of balance and intensity of physical activity [7]. In our study we focused on distinguishing between sedentary and non-sedentary time. Typical approach is recording accelerometer data in 1-min epochs and a threshold of <100 counts per minute (CPM) is chosen to classify sedentary time [3, 19]. Total sedentary time is calculated as a sum of all sedentary minutes, while each minute interval where number of accelerometer counts is above 100 is considered a non-sedentary break [19]. The current studies investigating sedentary behavior typically use dedicated devices such as ActiGraph, TriTrac, Caltrac, Actiwatch or

Actical [20] that directly provide the number of counts. On the other hand, accelerometers are widely available in smart phones due to their role in user interfaces [21]. Since mobile phones are providing the raw accelerometer signal, instead of calculating counts we opted for a simpler approach of analyzing standard deviation of accelerometer signal [7]. However, we compared the performance of the two approaches for inference of sedentary time in our experimental settings and they demonstrated comparable performance.

In our study we used a mobile phone; not only because it does not require an additional sensing device to be carried but also it does not impact the typical behavior routines of office workers. Clearly, an issue with technological monitoring is that subjects may not always wear the device and this is an issue that we will address in the upcoming studies. The typical approach to deal with this issue of using a 20-minute inactivity criterion to identify a non-wearing period was not applicable in our study as office workers may sit continuously for more than 20 minutes.

5. EXPERIMENTS AND RESULTS

We recruited 14 participants (9 males, 4 females), all of them office workers not connected with this study, for 5 working days (characteristics of the sample are shown in Table 1).

Table 1: Characteristics of the sample.

Age (years)	31.5±8.2
Work hours per week	38.5±2.0
Duration between two questionnaires (min)	203.1±39.4
Non-sedentary time in one interval (min)	39.3±19.2

The participants filled in the mood questionnaires in the beginning, in the middle and at the end of working day. There were no significant differences between men and women either in the relevant parameters (such as age, number of working hours or type of the job regarding sedentary routines) or in the measures (such as a number of reported positive/negative mood changes and average non sedentary time within one monitored interval). None of the participants was a cigarette smoker nor reported health problems. After discarding intervals due to non-completed reports, the data analyzed contained 151 monitored intervals, 74 and 77 intervals of positive and negative mood changes respectively. Self-reported mood change, measured as a difference in scores between two consecutive questionnaires, was analyzed regarding sedentary time, acquired using accelerometer embedded in smart phones. Statistical analysis was performed using SPSS while sedentary patterns were inferred with R-2.13.

Figure 1, Figure 2 and Figure 3 show the distributions of Spearman correlation between non-sedentary time and reported change in mood. The mean correlation between non-sedentary time and positive/negative/overall mood changes was 0.18±0.36 (*min*=-0.34, *max*=0.86), -0.23±0.37 (*min*=-0.90, *max*=0.33) and 0.35±0.38 (*min*=-0.48, *max*=0.86) respectively.

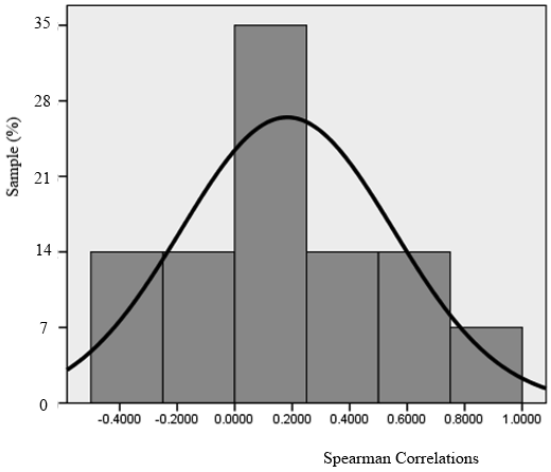

Figure 1: Distribution of Spearman correlation between non-sedentary time and positive mood score change.

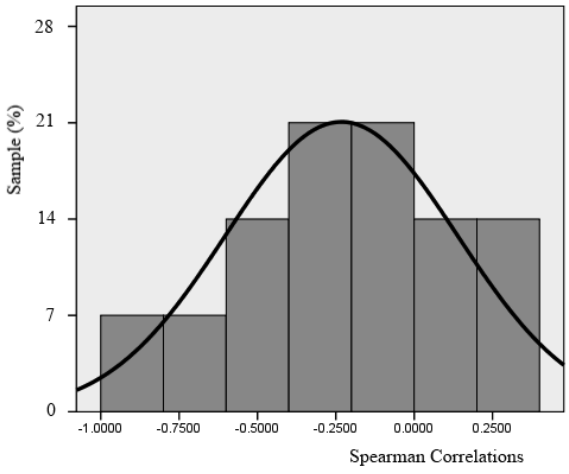

Figure 2: Distribution of Spearman correlation between non-sedentary time and negative mood score change.

The non-sedentary time/positive mood changes and non-sedentary-time/overall mood changes

distributions were significantly greater than 0 (t=1.753, t=3.451 respectively, P<0.1, P<0.005) while non-sedentary time/negative mood changes distribution was significantly less than 0 (t=-2.339 P<0.05). None of the distributions was significantly skewed.

The results suggest that the time spent in non-sedentary activities is positively correlated with changes in reported positive/overall mood and negatively correlated with changes in reported negative mood. On the other hand, the reported mood at the beginning of monitored intervals had moderately low impact on the sedentary behaviour in the following interval (r=0.24, r=-0.16 and r=0.23 respectively for initial positive/negative/overall mood score and non-sedentary time across subjects). This suggests that sedentary patterns were not influenced by subjects' mood

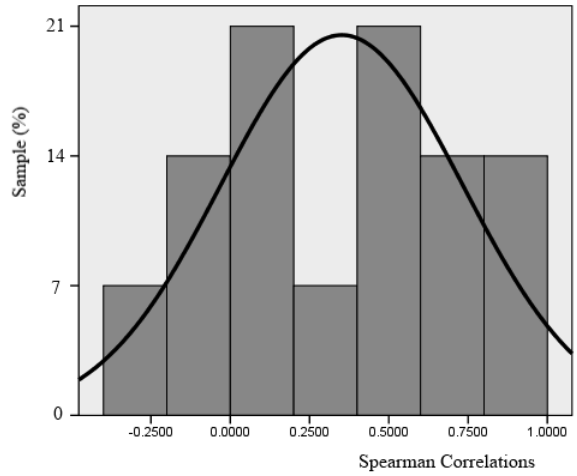

Figure 3 Distribution of Spearman correlation between non-sedentary time and overall mood score change.

6. CONCLUSION

Our pilot study has shown correlation between sedentary patterns at workplace and mood changes. Considering the potential health implications, this study provides a basis to establish new health recommendations and create work place policies that minimize sedentary work style, so that wellbeing of office workers is further improved. Use of mobile phones will allow workers to get feedback on their mood change scores and correlation with non-sedentary periods. This will form part of a persuasive feedback application that will be developed to encourage a healthy work style.

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