Sitmate: an android mobile application for the prevention of musculoskeletal discomfort among a business process outsourcing company workforce management personnel*

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Abstract

Introduction Due to COVID-19 pandemic, many have shifted into working at home which led to physical inactivity. This may cause musculoskeletal discomfort, chronic disease, muscle atrophy and spinal imbalance due to improper and prolonged sitting posture. Since mobile devices are relatively available for most of the office workers, there were still a lack of evidence-based mobile applications that can counteract the inactivity through exercises, which led to the researchers to create an application called SitMate that consists of evidence-based exercises which aimed to prevent musculoskeletal discomfort among a business process outsourcing company Workforce Management Personnel (BPO-WMP).

Methods Eleven participants (18-40 years old) full-time, work-from-home BPO-WMP were randomized into Treatment Group(TG)(n=6) and Control Group (CG)(n=5). The TG received one month intervention with the use of SitMate Application containing relaxation exercises, range of motion exercises and stretching exercises, and notifications for postural correction while the CG continued their usual working schedule.

Results There were no significant differences between two groups on all body parts that were measured using the Cornell Musculoskeletal Discomfort Questionnaire, and no significant differences in the intragroup pre-test and post-test scores on all body parts between TG and CG. For the intra-group post-test of the TG, there were noted improvements on the hip/buttock, right shoulder, upper back (median = 0) and right wrist (median = 1.5). There was also a noted increase in discomfort on the neck (median = 1.5) and lower back (median = 3). For the post-test of the CG, there were noted improvements on the right shoulder, right wrist (median = 0) and lower back (median = 1.5).

Conclusion This study has shown that the SitMate application does not effectively reduce the prolonged sitting-related discomfort among the personnel after 1 month of intervention.

Key words: SitMate, mobile application, musculoskeletal discomfort, Cornell Musculoskeletal Discomfort Questionnaire, concentric workforce management, office workers, prolonged sitting, physical inactivity, low back pain, relaxation exercises, posture

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The COVID-19 pandemic has caused many individuals from different fields into work-from-home arrangements leading to sedentary behaviors such as prolonged sitting and physical inactivity. This may cause musculoskeletal discomfort, chronic disease, muscle atrophy and spinal imbalance due to improper and prolonged sitting posture.[1-3] Approximately 60% of older adults report sitting for more than 4 hours per day, with over 54% watching television more than 3 hours and 65% sitting in front of a screen for over 3 hours.[4] On an 8-hour workday, employees sit 70.1 % of

the work time, translated to 5.6 hours of sitting time.[5] Prolonged sitting has detrimental effects on overall health.[6] This may cause musculoskeletal injuries such as neck, shoulder, and low back pain.[7] Physical activity prevents deleterious consequences of musculoskeletal problems, pain and improves function.[8,9] A decrease in non-specific low back pain is seen within a few weeks when treated with therapy such as aerobic, stretching, and stabilizing exercises.

Out of 379 eligible physical activity applications in one study, 45 had an alarm or a reminder feature, only seven for resistance training were evidence-based, four were based on physical activity reports, two were based on personal experience and no application for aerobic activities, stabilization, active range of motion and stretching was evidence-based.[10] This exposed the need for evidence-based mobile apps that can be used to enhance health outcomes.[11] The lack of evidence-based applications prompted the researchers to create SitMate, an application consisting of evidence-based exercises aimed to prevent musculoskeletal discomfort. The objective of this study is to evaluate the effectiveness of SitMate in preventing work-related disability among a business process outsourcing company Workforce Management Personnel (BPO-WMP).

Methods

The study used an experimental design where full time work-from-home management personnel from a business process outsourcing company were randomly assigned to the SitMate or control group for one month (August 9, 2021, to September 3, 2021). SitMate is an application developed by the researchers which included relaxation exercises and exercises designed to reduce musculoskeletal discomfort. No intervention was given to the control group. Musculoskeletal discomfort was measured at baseline and after one month using the Cornell Musculoskeletal Discomfort Questionnaire.[12] The difference in scores before and after the interventions were compared between the SitMate and control groups. The study was approved by the UERMMMCI Research Institute for Health Sciences Ethics Review Committee (ERC Code 0930/C/2021/011; approved April 26, 2021).

Participants included in this study were full-time workforce management personnel of a business process outsourcing company that worked from home of with an age-range of 18-40 years old, either single or married, had access to an Android mobile phone, at least a college graduate, and must be sitting continuously for at least 2.5 hours. The participants excluded from the study are those who had a history or current health conditions such as recent fractures, evidence of acute inflammatory or infectious processes such as Guillain-Barre, polymyositis, and dermatomyositis. Employees with osteoarthritis, sharp pain during joint movement and muscle elongation, joint instability, hematoma, deep venous thrombosis, severe cardiopulmonary diseases, cancer and communicable diseases such as SARS-CoV-2, tuberculosis and pneumonia were likewise excluded.. The computed sample size was 30 participants per group.

The intervention tested was SitMate, an application developed by the researchers which included relaxation exercises and exercises designed to reduce musculoskeletal discomfort based on available studies – active range of motion, flexibility, stabilization and aerobic. The postural exercises consisted of flexion-extension, elevation-depression, protraction-retraction, rotation, tilt, pump, weight-shifting and deep breathing. The daily exercises guide included marching in place, jogging in place, squats, shoulder circumduction, shoulder press, elbow flexion-extension, abdominal curls, shoulder flexion, shoulder abduction, running, lunges, bird dog, and leg raises. Exercises were progressive from Week 1 to Week 4 and were required to be done on work days. SitMate had reminder and alarm features. It also included instructional videos on how to do the exercises. Musculoskeletal discomfort was measured at the start and at the end of four weeks using the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ).[12]

The CMDQ is a 54-item questionnaire containing a body map diagram and questions about the frequency of musculoskeletal discomfort, severity of musculoskeletal discomfort and interference of musculoskeletal discomfort in the participants' work across 20 body parts specifically neck, upper back, shoulders, elbows, wrists, low back, hips/buttocks, thighs, knees and lower legs. Frequency of discomfort was calculated using a 5-point Likert scale: Never (0), 1 or 2 times/week (1.5), 3 or 4 times/week (3.5), every day (5) or several times a day (10). It was multiplied by the severity, scored using a 3-point Likert scale: slightly comfortable = 1, moderate uncomfortable = 2, very uncomfortable = 3 and interference rating with

3-point Likert scale: Not at all = 1, slightly interfered = 2, substantially interfered = 3. A high score indicated increased risk in having musculoskeletal discomfort. A video tutorial on how to answer the CMDQ was provided to both SitMate and control groups.

Qualified respondents who gave their informed consent were randomly allocated to either the SitMate or control groups through the block random sampling methods. The CMDQ, with a tutorial video, was sent to all participants at the start of the study. After completion of the CMDQ, the link to the SitMate application with a tutorial video on how to use the application was sent to the participants in the intervention group. All SitMate participants were monitored weekly for the accomplishment of tasks to make sure that the participants were doing the exercises as well as to check on their experience gained for progression. Any participant who reported increased pain and discomfort was withdrawn from the study. After the fourth week, the CMDQ sent to all participants in both the SitMate and control groups were collected for the post-intervention evaluation of musculoskeletal discomfort.

Data extracted from the CMDQ were encoded and analyzed using SPSS. The Wilcoxon-signed rank test was used to compare the pre- and post-intervention scores in each group. The Mann Whitney U test was used to compare the difference of the pre- and post-intervention scores between the SitMate and control groups. The level of significance was set at $p < 0.05$. Participants who did not finish the study were documented but not included in the analysis.

Results

Initially, there were 21 potential participants, however, only 18 responses chose to participate in the study. With the 18 responses received, 7 participants were excluded due to not having an Android phone, uncontrolled hypertension, joint instability or having equal to or less than 1hr and 30 minutes of sitting time hence only 11 participants were included. The 11 participants were then randomized to the treatment group (TG) and control group (CG). Six participants were allocated to the TG and five participants were allocated to the CG. One participant from the TG was withdrawn as the participant was not able to answer the CMDQ and did not receive the intervention.

There was no significant difference between the TG and the CG for the general characteristics (Table 1). There were no significant differences between two groups on all body parts that were measured using CMDQ, and no significant differences in the intragroup pre-test and post-test scores on all body parts between TG and CG (Table 2). However, it is noted that there was a slight improvement in comparing the changes between TG and CG in the hip/buttocks (median = -1.5). For the intra-group post-test of the TG, there was noted improvements on the hip/buttock, right shoulder, upper back (median = 0) and right wrist (median = 1.5). There was also a noted increase in discomfort on the neck (median = 1.5) and lower back (median = 3) (Tables 3 & 4). In contrast, for the post-test of the CG, there were noted improvements on the right shoulder, right wrist (median = 0) and lower back (median = 1.5).

Table 1. General demographics of the participants.

Characteristics		Participants	
		Treatment (n=5)	Control (n=5)
Sex	Male	4	3
	Female	1	2
Age	Median Age	40 yrs.(33-40)	33 yrs.(31-40)
Cumulative Duration Sitting Per Day	2 Hrs & 30 Min.	2	2
	Greater than 2 Hrs & 30 min.	3	3
Educational Attainment	College Graduate	5	5
	Master's Degree	0	0
	Doctorate Degree	0	0

*Unless specified, data are presented as median (interquartile range (IQR))

Table 2. Comparison of the difference in both treatment group and control group after 1 month.

Body Parts	Changes in TG	Changes in CG	Between-Group p
Neck	0 (0-3)	0 (0-0)	0.310
Right Shoulder	0 (-1.5-0)	0 (-1.5-0)	0.690
Left Shoulder	0 (-1.5-0)	0 (-1.5-1.5)	1.000
Upper Back	0 (-1.5-1.5)	0 (0-1.5)	0.421
Right Upper Arm	0 (0-3)	0 (-2-1.5)	0.421
Left Upper Arm	0 (-1.5-1.5)	0 (-1.5 - 1.5)	1.000
Lower Back	0 (-3-3.5)	0 (-18.5-1.5)	0.421
Right Forearm	0 (-3-0)	0 (0-4.5)	0.222
Left Forearm	0 (0-6)	0 (0-1.5)	0.421
Right Wrist	0 (-7-10.5)	0 (-1.5 - 12.5)	0.841
Left Wrist	0 (0-6)	0 (0-0)	0.310
Hips/ Buttocks	-1.5 (-3.5-0)	0 (-12.5-0)	0.548
Right Thigh	0 (0-6)	0 (0-1.5)	0.548
Left Thigh	0 (0-6)	0 (0-1.5)	1.000
Right Knee	0 (0-3)	0 (-1.5-0)	0.222
Left Knee	0 (0-3)	0 (0-0)	0.690
Right Lower Leg	0 (0-6)	0 (0-1.5)	1.000
Left Lower Leg	0 (0-6)	0 (0-0)	0.690

Data are presented as median (interquartile range (IQR)). Mann- Whitney U Test was performed for intergroup comparisons, p for significant change difference between groups (<0.05).

Table 3. Comparison of the pre-test and post-test score of the treatment group after 1 month.

Body Parts	Pre-test Score of the Treatment Group	Post-test Score of the Treatment Group	Intra-group p-value
Neck	0 (0-1.5)	1.5 (0-3)	0.180
Right Shoulder	1.5 (0-1.5)	0 (0-1.5)	0.157
Left Shoulder	0 (0-3)	0 (0-3)	0.655
Upper Back	1.5 (0-3)	0 (0-3)	0.564
Right Upper Arm	0 (0-0)	0 (0-3)	0.180
Left Upper Arm	0 (0-0)	0 (0-6)	0.317
Lower Back	1.5 (0-3.5)	3 (0-5)	0.715
Right Forearm	0 (0-0)	0 (0-3)	0.180
Left Forearm	0 (0-0)	0 (0-6)	0.317
Right Wrist	3 (0-7)	1.5 (0-14)	1.000
Left Wrist	0 (0-0)	0 (0-6)	0.180
Hip/Buttock	1.5 (0-3.5)	0 (0-0)	0.102
Right Thigh	0 (0-0)	0 (0-6)	0.180
Left Thigh	0 (0-0)	0 (0-6)	0.317
Right Knee	0 (0-0)	0 (0-3)	0.180
Left Knee	0 (0-0)	0 (0-3)	0.317
Right Lower Leg	0 (0-0)	0 (0-6)	0.317
Left Lower Leg	0 (0-0)	0 (0-6)	0.317

Data presented as median (interquartile range (IQR)). Wilcoxon-signed rank test was performed for intragroup comparisons.

Table 4. Comparison of the pre-test and post test score of the control group after 1 month.

Body Parts	Pre-test Score of the Control Group	Post-test Score of the Control Group	Intra-group p value
Neck	0 (0-1.5)	0 (0-1.5)	0.564
Right Shoulder	1.5 (0-3.5)	0 (0-3.5)	0.317
Left Shoulder	0 (0-3)	0 (0-1.5)	1.000
Upper Back	0 (0-1.5)	0 (0-1.5)	0.317
Right Upper Arm	0 (0-3.5)	1.5 (0-1.5)	0.655
Left Upper Arm	0 (0-1.5)	0 (0-1.5)	0.564
Lower Back	3.5 (0-20)	1.5 (0-5)	0.285
Right Forearm	0 (0-1.5)	0 (0-6)	0.317
Left Forearm	0 (0-1.5)	0 (0-1.5)	0.317
Right Wrist	1.5 (0-1.5)	0 (0-14)	1.000
Left Wrist	0 (0-1.5)	0 (0-1.5)	0.317
Hip/Buttocks	1.5 (0-14)	1.5 (0-3.5)	0.317
Right Thigh	0 (0-3.5)	0 (0-3.5)	0.317
Left Thigh	0 (0-1.5)	0 (0-1.5)	0.317
Right Knee	0 (0-1.5)	0 (0-1.5)	0.317
Right Lower Leg	0 (0-0)	0 (0-1.5)	1.000

Data are presented as median (interquartile range (IQR)). Wilcoxon -signed rank test was performed for intragroup comparisons

The likelihood of delayed-onset muscle soreness to occur when using the SitMate Application every 5 days is 0.588 case in weeks 1 and 2, 0 case in week 3, and 0.526 case in week 4.

Discussion

To the best of the authors' knowledge, SitMate is the first mobile application to incorporate postural awareness and weekly relaxation exercise with its corresponding progression. In addition, this study is the first to use CMDQ to evaluate the effectiveness of SitMate among a business process outsourcing company workforce management personnel (BPO-WMP).

In contrast to the previous study on reducing musculoskeletal discomfort conducted among office workers which was implemented for a month by encouraging the participants to "stand-up and sit-less" every 30 minutes, resulted to a significant decrease in sitting time possibly leading to decreased discomfort in the neck, upper arm, upper back, low back and hip/thigh.[5,13,14,15,16,17] In the SitMate application, it has the same feature where the participants are encouraged to stand up every 30 minutes[5,18,19] with incorporation of relaxation exercises which was supported by providing exercises such as cervical spine motions[20], scapular motions[21] and stretching of major muscle groups to reduce muscle aches, pain, and stiffness during prolonged sitting.[5,9,18-21] Based on the evidence provided in these supporting articles, the researchers expected that the discomfort score would decrease among participants who received the SitMate intervention. Nonetheless, there was no statistically significant improvement based on the Cornell Musculoskeletal Discomfort Questionnaire in comparison to the pre-test and post-test scores of the Treatment Group. However, it's important to note that the scheduling of progression for the SitMate intervention was based on the completion of adverse effect forms at the end of each week. These forms were only accessible to participants once they finished the prior week. Surprisingly, 60% of the participants took longer than the designated timeframe to complete the first and second weeks, 80% exceeded the third-week timeframe, and 100% exceeded the fourth-week timeframe. As a result, there is a possibility that some participants did not receive the intended relaxation intervention as intended due to the delay in progressing through the specified timeframe. Moreover, studies conducted had shown that sustaining prolonged posture heavily contributes to having musculoskeletal discomfort causing improper joint loading on cervico-thoracic and lumbosacral joint, and spinal imbalance.[18,22,23] Another study where either healthy workers or workers with chronic low back pain experienced low back pain due to the assumption of slumped posture after 20 minutes during an hour of sitting.[5] Therefore, the importance

of correcting posture every 20 minutes per hour can help in reducing musculoskeletal discomfort.[18] Based on the study results and the observed delayed progression of participants, it is plausible to infer that some participants may not have fully complied with the suggested postural correction, which was delivered through their cell phones every 20 minutes per hour during work hours. This lack of compliance could have contributed to the prolonged discomfort and exceeded timeframes for the SitMate intervention, potentially affecting the overall effectiveness of the intervention in reducing discomfort scores. Further analysis and investigation would be required to understand the reasons behind the non-compliance and its impact on the study outcomes.

Numerous studies have demonstrated that mobile applications are effective tools for improving health outcomes. For instance, the NeckProtector mobile app has been shown to effectively reduce neck pain by incorporating stretching exercises and encouraging reduced sitting time.[11,23,24,25] Considering these positive results, it is recommended that mobile health applications should include pre-programmed training plans aimed at reducing prolonged sitting.[26] On the other hand, for practical application of SitMate, it may not significantly reduce musculoskeletal discomfort among office workers, however it can reduce their sitting time and improve their health outcomes by providing additional knowledge on how the body functions during a specific relaxation exercise and by promoting muscle activity.[11] By incorporating SitMate as a guide, office workers have the opportunity to proactively address several health concerns associated with their sedentary work environment. Regular use of SitMate can help reduce physical inactivity, which, in turn, lowers the risk of cardiovascular diseases and diabetes. The app's guidance on Range of Motion (ROM), aerobic exercises, stretching, and stabilization exercises can be beneficial in improving venous return in the lower limbs and reducing the risk of muscle atrophy.

Through its well-designed exercise programs, SitMate empowers users to safely perform the specified exercises, ensuring proper form and technique. By engaging in these exercises, office workers can counteract the negative effects of prolonged sitting, promoting better overall health, and enhancing their physical well-being. Embracing SitMate as a part of their daily routine can lead to a more active and healthier lifestyle, mitigating the adverse effects of sedentary behavior in the office environment.[13,27,28] Moreover, the inclusion of timed postural reminders in the SitMate application prompts users to adopt and maintain proper posture throughout their workday. These reminders play a crucial role in reducing the risk of muscle imbalances on the spine. By promoting regular adjustments to ergonomic positions, SitMate helps users prevent strain on specific muscle groups and encourages a balanced distribution of stress on the spine. Consistent use of the app's postural reminders can lead to improved musculoskeletal health and a reduced likelihood of developing discomfort or injuries related to poor sitting posture.[18,22]

Overall, SitMate holds great significance when used properly during working hours, especially for work-from-home office workers. By providing guided exercises, postural reminders, and promoting regular movement, SitMate can effectively decrease the risk of musculoskeletal discomfort and systemic complications such as cardiac and metabolic conditions. With many office workers facing physical inactivity due to their current work-from-home setups, the app's features address the specific challenges of sedentary behavior in this context.

By incorporating SitMate into their daily routine, office workers can proactively combat the negative effects of prolonged sitting and reduce the likelihood of developing health issues associated with a sedentary lifestyle. The app's comprehensive approach to promoting proper posture and regular exercise makes it a valuable tool for enhancing overall health and well-being, ensuring a more balanced and active workday for users.

In this study, the SitMate mobile application did not demonstrate a significant reduction in prolonged sitting-related discomfort scores on the CMDQ among the BPO workforce management personnel after 1 month of intervention. However, the researchers recommend further investigation by assessing the ergonomics of the participants and ensuring consistent usage of the application throughout the entire research protocol. The limited number of participants in the study was influenced by factors such as the availability of participants and the prevalence of the current work-from-home setup, which made recruitment challenging.

To achieve more robust results, future studies should focus on recruiting a minimum computed sample size of individuals who are prone to prolonged sitting for 2 ½ hours or more. Additionally,

ensuring consistent usage of the SitMate application throughout the intervention period will provide a clearer understanding of its impact on reducing discomfort and promoting healthier sitting habits among BPO workforce management personnel. By addressing these considerations, future research may yield more conclusive and beneficial findings regarding the effectiveness of SitMate in mitigating prolonged sitting-related discomfort in the context of a remote work environment.

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Conflict of interest declaration

The researchers declare that the study has no existing conflict of interest.

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