Proceedings of the 10th World Congress on Electrical Engineering and Computer Systems and Sciences (EECSS'24)
Barcelona, Spain – August 19 - 21, 2024
Paper No. ICBES 128
DOI: 10.11159/icbes24.128

The Relationship among Seated Pressure Distribution, Posture and Discomfort Across A Seated Task: A Pilot Study

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Abstract – The rise in computing technology has prolonged sedentary behaviour, which is alarmingly increasing the number of population suffering from back pain. Poor posture during extended sedentary periods in which office workers are sitting down and operating a computer, is a major cause of back pain. Detecting postural change is an important step in addressing this issue. However, such detection usually requires attachment of position sensors to the body which can hinder body movements in seated positions. This pilot study utilised CONFORMAT pressure mat to investigate if seating pressure can predict discomfort levels of different body parts along with postural changes during 30 minutes of sitting. The study involved one female participant sitting for 30 minutes while working on a computer. During sitting, Peak Pressure Ratio (PPR) was measured in 5 minute intervals, and the number of postural shifts were measured over the first 3 and last 3 minutes. Borg's scale was also used to evaluate the level of discomfort of different body regions. Results showed that the buttocks were the major areas of discomfort. Across the 30 minutes of sitting, there was strong significant ($p<0.05$) correlation between PPR and Borg's scores at the neck, shoulder and buttock regions ($r = 0.94, 0.85, 0.87$ respectively). Meanwhile, a positive relationship was found between the number of postural shifts and Borg's scores after prolonged sitting as well (Increase of postural shifts from 21 to 23 in the last 3 minutes of the task along with an increase of 1.45 from 0.95 for average Borg scores). The findings of this study provide insight into the use of pressure sensing mats in predicting onset of discomfort over body parts along with postural changes during prolonged sitting.

Keywords: Posture, sensors, pressure, discomfort, seating

1. Introduction

In Australia, a majority of workers spend approximately 76% of their time at work sitting [1]. Additional sedentary activities such as TV viewing and riding a vehicle also consume large amounts of time in the average person's day to day life. Sitting is an everyday activity which contributes to 40-90% more pressure on spinal discs when compared to standing [2]. 63% of office workers report musculoskeletal pain symptoms attributing to their jobs across a 12-month prevalence [3]. Sitting for a prolonged time combined with bad posture creates neck curves, which leads to neck alignment issues. This results in weakening of the upper back muscles, making them unable to hold the body upright. Thus, the body and begins to curve and strain which creates discomfort [4]. Whilst taking a break and performing stretching exercises can help address the seated discomfort, a lot of people fail to do so. Technologies can be developed to help detect postural changes and remind people to take action before back pain starts to develop. Wearable sensors attached to the upper body can measure postural changes directly. However, they can hinder movements during sitting and cause further discomfort. Pressure Mat Sensors could be a feasible method for posture detection, because changes in postures of the upper body could alter the seat pressure distribution. The advantage here is that no sensor attachment to the body is required. By monitoring postural changes, it was hypothesized that the onset of back pain can be predicted. In this study, we studied the relationship among seat pressure, discomfort perception at upper body, and postural shifts over 30 minutes of sitting. This serves as an important step in enabling an innovative way of using seat pressure to predict postural changes and back pain/discomfort.

2. Methods

2.1. Participants

The participant was a 22.2-year-old female who had a healthy BMI between 18.5 and 24.9 kg/m^2 and no pre-existing musculoskeletal conditions or pain which could cause biased results in the study.

2.2. Instruments & Procedure

The Interface Pressure of the seated position was measured using Tekscan's CONFORMat™ system. The CONFORMat provides accurate & real-time pressure distribution data using sensors that 'conform' to the shape of the patient, resulting in highly accurate pressure readings (CONFORMat System, 2016). The CONFORMat was placed and fixed on a flat cushioned chair with thin double sided adhesive tape to ensure there was no movement during testing which might interfere with pressure readings.

The participant sat while working on a computer for 30 minutes (work was a mix of typing, scrolling and reading). During the 30 minutes, interface pressure of the buttocks was continually measured, and the Borg CR-10 discomfort scale was used to measure discomfort levels every 5 min. An Apple iPad was used to video record the experiment for ground truth data. Human research ethics was exempted because of the negligible risks of this research.

2.3. Data Collection and Analysis

At 5-minute time intervals, Borg CR-10 scores verbally reported by the participant were recorded. A list of areas of the body (Shoulder, neck, buttocks, thighs, upper & lower back) in which the Borg CR-10 score were taken for was displayed 1 meter in front of the participant so that they knew what areas they were to state scores for. Meanwhile, seat pressure data was collected using the 'CONFORMat Research' program and included parameters of Peak Force, Contact Pressure, and Object Pressure at the ischial tuberosity. Post-testing, the Peak Pressure Ratio (Ratio between the highest peak pressure and lower peak pressure in the ischial tuberosity region) was calculated, along with the number of postural shifts (This was calculated by analysing the dispersion index (DI) across the first and last 3 min of the test. DI is a relative measure of the load on the sitting surface given by the load of the tuberal zone divided by the total load on the sitting surface. A postural shift was defined when the dispersion index varied by +/-10% and +/-20%.). Pearson correlation coefficient was used to determine the strength of correlation among PPR, and Borg CR-10 scores. Borg CR-10 scores were considered for each body area as a whole, instead of separating left and right. The participant was asked to state their discomfort score disregarding for the left and right side of each body region however the score used in the data analysis was the highest value out of the left or right region.

Fig. 1: CONFORMat setup on chair

Fig 2: Participant sitting on chair & doing task.

3. Results & Discussion

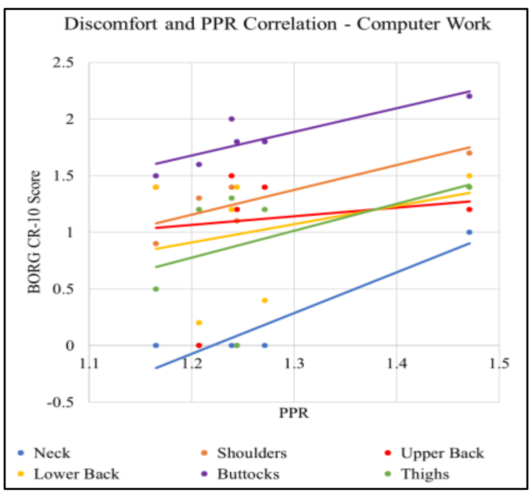

Fig 3: Correlation between discomfort & PPR for Computer Work

Table 1:Correlation & significance of PPR & overall discomfort scores

Areas of the body	PPR Significance	r Values	Discomfort Score (First 3 minutes)	Discomfort Score (Last 3 minutes)
Neck	0.05	0.94	0	1
Shoulder	0.033	0.85	0.9	1.7
Upper Back	0.783	0.15	1.4	1.2
Lower Back	0.558	0.3	1.4	1.2
Buttock	0.025	0.87	1.5	2.2
Thighs	0.363	0.46	0.5	1.4
Overall discomfort Score (Average)			0.95	1.45

Table 2: Number of Postural Shifts during first 3 minutes & the last 3 minutes of the task

Time (Minutes)	1	2	3	28	29	30
No. of Postural Shifts	6	9	6	10	7	6

Borg score and Peak Pressure Ratio (PPR) generally increased over the 30 minutes of sitting (See figure 3 and table I). The neck, shoulder and buttock regions showcased strong correlation between Borg CR-10 discomfort scores and PPR (r = 0.94, 0.85, 0.87 respectively). Furthermore, these correlations also showcase statistical significance ($p<0.05$, see Table I). Discomfort of the neck and shoulder regions which developed over time, could be explained by using an arm to operate the laptop mouse, This movement engages the shoulder muscles leading to discomfort in the area [5]. Neck flexion occurs during working on computers, which creates 5 times more forces on the neck muscles compared to sitting upright. As a result, high levels of discomfort can be felt in the neck region. Along with the shoulders and neck, the buttocks were found to be one major area of discomfort, consistent with the findings from other studies [6]. This can be explained by significantly higher pressure measured at the regions of ischial tuberosity. During sitting, the buttock muscle which is directly under the ischial tuberosity is in compression. Lactic acid accumulates as a result of these compression forces, which in turn causes pain [7], resulting in high level of discomfort in the buttocks. The significantly strong correlations between Borg CR-10 scores and PPR showed that the discomfort over the shoulders, neck and buttocks can be predicted by seated pressure. Throughout this test, it was found that the number of postural shifts increased from 21 in the first 3 minutes to 23 in the last 3 minutes. In addition to this, discomfort scores for the shoulders, neck and buttocks all increased too (See table I). This indicates a strong relationship between the number of postural shifts and Borg's scores after prolonged sitting.

4. Conclusion

This study found high correlations between seated pressure and discomfort in different body regions, particularly showing significant results for neck, shoulders, and buttocks. Buttocks discomfort reached a score of 2.2 in the Borg CR-10 scale, making it one of the highest reported discomfort areas. Postural shifts were also detected by pressure mats where a general positive correlation was found between the number of postural shifts and discomfort. Overall, this study demonstrated the feasibility that pressure sensing mats can help predict the level of discomfort over upper body along with postural changes during prolonged sitting.

Acknowledgements

Acknowledgements provided to the University of Wollongong for providing necessary equipment and lab resources to carry out this project.

References

[1] S. NSW, "Sedentary work," *SafeWork NSW*, Aug. 16, 2018. https://www.safework.nsw.gov.au/safety-starts-here/physical-safety-at-work-the-basics/sedentary-work

[2] "Ergonomics of sitting," *ergo.human.cornell.edu*, 2022.

[3] P. Janwantanakul, P. Pensri, V. Jiamjarasrangsri, and T. Sinsongsook, "Prevalence of self-reported musculoskeletal symptoms among office workers," *Occupational Medicine*, vol. 58, no. 6, pp. 436–438, Jun. 2008, doi: https://doi.org/10.1093/occmed/kqn072.

[4] Orthopedics and S. Medicine, "The Dangers of Too Much Sitting And How it Harms The Body," *NewYork-Presbyterian*, Sep. 19, 2019. https://healthmatters.nyp.org/is-too-much-sitting-harming-your-body/

[5] LeamingtonOsteopaths007, "Mouse Shoulder - Jane OConnor & Associates | Osteopaths UK," *Jane OConnor & Associates*, Apr. 11, 2023. https://leamington-osteopaths.co.uk/mouse-shoulder/ (accessed Mar. 20, 2024).

[6] Pooriput Waongenngarm, van, Prawit Janwantanakul, Nipaporn Akkarakittichoke, and P. Coenen, "Can the Borg CR-10 scale for neck and low back discomfort predict future neck and low back pain among high-risk office workers?," vol. 95, no. 9, pp. 1881–1889, Jun. 2022, doi: https://doi.org/10.1007/s00420-022-01883-3.

[7]C. R. Mehta and V. K. Tewari, "Seating discomfort for tractor operators – a critical review," *International Journal of Industrial Ergonomics*, vol. 25, no. 6, pp. 661–674, Jul. 2000, doi: https://doi.org/10.1016/S0169-8141(99)00054-2.