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Impact of Prolonged Sitting on Well-being and Productivity among Computer Workstation Users: Ergonomic Study

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Abstract

A computer workstation/workplace is one where the majority of work is accomplished by using a computer, keeping a record in hard and soft copy and communicating over the telephone. Most computer workstation is sedentary in nature and often include prolonged sitting without break. Computer workstation often involves sitting for long hours to get the jobs done. Studies have shown that prolonged seating in the workplace leads to musculoskeletal discomforts, increased risks of cardiovascular diseases and overweight. In present study, a questionnaire-based self-feedbacks survey was undertaken so as to study the various relationship of prolonged sitting and computer workstation setups with regards to overweight, the prevalence of musculoskeletal disorders and perceived comforts levels and productivity of workers. Data were then analyzed using IBM SPSS (version 22). It was found that prolonged sitting time has significant impacts on overweight, lower levels of comforts and productivity among workers. There is also a significantly high prevalence of Musculoskeletal discomforts among workers who are subjected to prolonged seating working hours. The result shows that different workstation setup affects different parts of the user body. It is recommended that a flexible sit-stand table should be adopted to reduce negative impacts.

Keywords: Computer Workstation; Sedentary; Comforts; Productivity

Abbreviations: MSD: Musculoskeletal Disorders; BMI: Body Mass Index; CST: Continuous Sitting Time; DST: Daily Sitting Time; PCL: Perceived Comfort Level; PLP: Perceived Levels of Productivity; BP: Back Pain.

Introduction

A computer workstation/workplace is one where the majority of work is accomplished by using a computer, keeping a record in hard and soft copy and communicating over the telephone. Most computer workstation is sedentary in nature and often include prolonged sitting without break. Studies have shown that prolonged sitting in the workplace often leads to discomforts and development of several health issues such as for overweight, increased risk of Diabetes Mellitus, cardiovascular disease etc. Aside from overweight and Musculoskeletal Disorders (MSD). Aside van Uffeln, et al. noted in their review paper that occupational sitting is associated with higher risks of mortality [1].

Jakicic JM show that sedentary behaviour is positively associated with overweight and obesity [2]. Dunstan, et al. in their studies concluded that the use of technology (computer) leading to prolonged sitting is associated with overweight [3]. In one study it is found that hours of spend on watching television is positively associated with overweight in children

[4]. Researchers have attributed the cause of overweight to physical inactivity and decrease the rate of metabolism [5,6]. However, studies also found no association between sitting time and overweight [7]. We, therefore, hypothesized that,

$H1_0$: There is no association between overweight and workplace sitting time.
$H1_a$: There is a significant association between overweight and workplace sitting time.

US Bureau of Labor Statistic (www.bls.gov) reported that MSD is the single largest category of workplace injuries. MSD are injuries and disorders which affects human body movement or musculoskeletal system i.e. ligaments, nerves, muscles, tendons, blood vessels etc. Shariat A, et al. found that prolonged standing and sitting induced MSD in worker's majority been Back pain [8]. Moom, et al. pointed out there is a huge prevalence of MSD among computer bank employee in Punjab [9]. James, et al. shown that computer usage in university is linked with a higher risk of MSD [10]. The ill effect can be attributed to continuous static loading on the body parts and improper posture leading to un monitor stress in body parts [11]. We, therefore, hypothesized that,

$H2_0$: There is no association between MSD prevalence and workplace sitting time.
$H2_a$: There is a significant association between MSD prevalence and workplace sitting time.

Wennberg P, et al. noted that working in a particular position for longer periods are known to induced stress and reduce concentration in workers [12]. Alkhajah TA, et al. [13], Hall J, et al. [14] noted that given an option between enhance flexible workstation and fixed workstation workers preferred working on the flexible workstation and reported significant improvement in comfort and productivity. Sitting for long periods can induce MSD in workers which cause distraction and sometimes reduces mobility [13,15].

$H3_0$: There is no association between workplace sitting time and user-perceived comforts and productivity
$H3_a$: There is a significant association between workplace sitting time and user-perceived comforts and productivity

Different workplace setting affects different parts of the body with different intensity, for example with adjustable monitor angles users can change according to their needs thus implying the ability to changes neck posture. Michael Y Lin, et al. [16] noted that different workstation setups induce different magnitudes and range of posture and muscle activity. Kingma and van Dieen [17] noted that the removal of back support induces users to support their body weight by leaning forward and placing their forearms on the desks. We thus hypothesized that,

$H4_0$: There are no differences in the degree of impact of different workstation setups on prevalence's of various discomfort
$H4_a$: There is a significant difference in the degree of impact of different workstation setups on prevalence's of various discomfort

Studies also have shown that the effect on health varies across Socio-economic structure, the difference in food habits, ethnicity etc. [6,15]. The aim of this paper was to study the impact of computer workstation on workers wellbeing and productivity of Punjab State. And also study the impact of various workstation setups on the prevalence of various discomforts.

Methodology

Study Design

Participants are selected from across the different region of Punjab and across different workplace. A self-assessment questionnaire is design and data are collected physically on printed pages or through google form. Snowball sampling method was adopted and a total of 263 candidates submitted the feedback form within a period of Sept.18-Jan.19, the sample size was determined using the equation:

$$SS = \frac{Z^2 * P(1-P)}{C^2} \quad \text{Eq (1)}$$

Where
SS=Sample size
Z= Standard normal deviation
P=Proportion of the target population with a particular characteristic
C= Confidence Interval

Snowball sampling methods was adopted so as to minimize the misreporting by the non-eligible person and also to targets specified person across the different workplace. Data analysis was carried out using a statistical tool package (SPSS v22) to test the hypothesis. The result is then used to recommend suitable computer workstation.

Inclusion and Exclusion Criteria of Participants

Inclusion criteria include any person who uses a computer to accomplish the majority part of their job are qualified for the study. Example: customer's attendee (calls-centre) Bankers, students or researchers, Office staff and clerks etc. Exclusion criteria include Mothers who are pregnant or in lactation periods, a person who has undergone

major surgeries or sustained major injury recently.

Measures

For tabulation of Body Mass Index (BMI), weight in kg and height in cm is collected. Continuous Sitting Time (CST) and Daily Sitting Time (DST) are collected in graded range value. Perceived Comfort Level (PCL) and Perceived Levels of Productivity (PLP), of the present workstation, is indicated range 1-10, with 1 representing extremely uncomfortable/ inefficient and 10 extremely comfortable/efficient resp. Prevalence of occurrence of various MSD or discomfort is graded accordingly as Extremely frequent > very frequent > frequent > occasional > never. Information about the feature of present workstation with respect to adjustability is graded as *Yes-Slightly-No*.

Statistical Analysis

Collected data are first exported to respective IBM SPSS (version 22) file format from both the physical forms and through google forms for further analysis. Descriptive statistical analysis was carried out to determine the nature of data. Spearman correlation analysis is carried out to determine the correlation between sitting time and overweight, the prevalence of MSD and perceived comfort and productivity. Next, Linear regression analysis was conducted to see how well the association is explained. Further, a multiple regression analysis was carried out to determine how the difference in workstation adjustability option affect the prevalence of various discomfort.

Results

Of the 263 participants, 179 are males and 84 are females with median ages of 25 years. Heights and weight of participants range between 145-186 cm and 45-95 kgs with medians of 165 cm and 66 kgs respectively. The average reported continuous and total daily sitting time is 1:30-2:00 hours and 5:00-6:00 hours respectively.

Relationship between Sitting Time and Overweight's

A two-tailed Spearman's correlation yield correlation factor of 0.729, significant at 0.01 level (Table 1) indicating a strong association between daily sitting time and BMI. Linear Regression analysis yielded R squared value of 0.537 significant at a 95% confidence interval and linear model of:

$$BMI=1.844\ DST+0.238\ CST+17.171 \quad \text{Eq (2)}$$

Further part correlation gives 0.666 and 0.139 for daily sitting time and continuous sitting time indicating the prominent association between daily sitting time and overweight over continuous sitting time.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig	Correlations		
	B	Std. Error	Beta			Zero-order	Partial	Part
Constant	17.171	.424		40.524	000			
Cont_time	.238	.105	.107	2.260	.025	.417	.139	.095
Daily_sitting	1.844	.128	.680	14.394	.000	.729	.666	.605

Table 1: Linear Regression analysis of CST and DST with BMI.

Relationship between Continuous Sitting Time and the Prevalence of MSD

The Spearman's correlation for continuous sitting time and prevalence of various MSD is given in Table 2. The correlation factor for back, shoulders and hip/buttock pain yielded 0.603, 0.567 and 0.771 respectively indicating a high significant strong association with continuous sitting time. However, the correlation factor for neck stiffness yielded 0.389 indicating a mild association with continuous sitting time. Further linear regression analysis of Back Pain (BP) with continuous sitting time and daily time gives equation (3) with an R squared value of 0.371.

$$\text{Prevalence of BP}=0.478\ CST-0.001DST+1.789 \quad \text{Eq (3)}$$

Similarly, for shoulders pain, it yielded equation (4) with an R squared value of 0.339.

$$\text{Prevalence of SP}=0.485CST-0.077DST+1.177 \quad \text{Eq (4)}$$

Also, linear regression analysis of Hip/Buttock (HP) gives equation (5) with an R squared value of 0.601.

$$\text{Prevalence of HP}=0.569CST-0.074DST+0.856 \quad \text{Eq (5)}$$

Thus, indicating a strong association of continuous sitting time with prevalence of back, shoulders, and hip/buttock pain and mild association with neck stiffness.

	Cont. time		Prevalence of (MSD)				
			Back	Shoulders	Hip/Buttock		Neck
Spearman's rho	Cont. time	Correlation Coefficient	1.000	.603**	.567**	.771**	.389**
		Sig. (2-tailed)	.	.000	.000	.000	.000
		N	263	263	263	263	263

Table 2: Spearman's correlation of CST with the prevalence of MSD.

Relationship of Sitting Time with Perceived Comfort and Productivity

Spearman's correlation of continuous sitting time with perceived Comfort and Productivity (Table 3) gives a correlation factor of -0.883 and -0.682 respectively indicating a strong negative association. Also, Spearman's correlation of daily sitting time (Table 3) yielded correlation factors -0.385 and -0.288 resp. Moreover, Spearman's correlation of prevalence of Fatigue/Headaches (Table 3) gives correlation factors of 0.770 which also adds to the discomfort of users. Further linear regression analysis of perceived comfort with continuous sitting and daily sitting time gives equation (6) with adjusted R square of 0.759

$$PCL=-1.228CST+0.027DST+10.654 \quad \text{Eq (6)}$$

Similarly, perceived productivity yielded equation (7) with an adjusted R squared of 0.515 resp.

$$PLP=-1.040CST+0.081DST+9.926 \quad \text{Eq (7)}$$

			Cont. time	Perceived		Prevalence
				Comfort	Productivity	Fatigue/Headaches
Spearman's rho	Cont. time	Correlation Coefficient	1.000	-.883**	-.682**	.770**
		Sig. (2-tailed)	.	.000	.000	.000
		N	263	263	263	263

Table 3: Spearman's correlation of CST with PCL, PLP and prevalence of Fatigue.

Degree of the Impact of Different Workstation Setup on the Prevalence of Various Discomforts

Spearman's correlation of various prevalence of various discomforts with workstation setups yields different correlation coefficient showing different degree of association. Back pain prevalence has most degree of association with reclining chair adjustability i.e. -0.365, while Shoulders pain prevalence has most degree of association with chair back supports height. Similarly, Hip/ Buttock has a high degree of association with monitor angles adjustability and table height of correlation coefficient of -0.548 and -0.524 resp. Neck stiffness is highly associated with the adjustability of monitors angles with a correlation coefficient of -0.626. However, eyes strain shows little or no degree of association with the mention different workstation setups.

			Discomfort	Adjustability option for			
				Table height	Reclining chair	Monitor angle	Chair back support height
Spearman's rho	Prevalence Back pain	Correlation Coefficient	1.000	-.273**	-.365**	-.151**	-.302**
		Sig. (2-tailed)	.	.000	.000	.014	.000
		N	263	263	263	263	263
	Shoulders pain	Correlation Coefficient	1.000	-.371**	-.305**	-.369**	-.591**
		Sig. (2-tailed)	.	.000	.000	.000	.000
		N	263	263	263	263	263

Spearman's rho	Hip/Buttock pain	Correlation Coefficient	1.000	-.524**	-.258**	-.548**	-.360**
		Sig. (2-tailed)	.	.000	.000	.000	.000
		N	263	263	263	263	263
	Neck Stiffness	Correlation Coefficient	1.000	-.166**	-.626**	-.397**	-.394**
		Sig. (2-tailed)	.	.007	.000	.000	.000
		N	263	263	263	263	263
	Eye Strain	Correlation Coefficient	1.000	-.249**	-.197**	-.162**	-.280**
		Sig. (2-tailed)	.	.000	.001	.009	.000
		N	263	263	263	263	263

Table 4: Spearman's correlation of various discomfort with different computer workstation setups.

Discussion

The goal of the current study is to study the impact of prolonged sitting on workers wellbeing and perceived productivity. The result indicates that prolonged sitting has a negative impact on workers well-being and productivity. The correlation coefficients range from -0.288 to as high as -0.883 indicating the variability in the association of various parameters.

The correlation coefficient of 0.740 between overweight and daily sitting time indicates a strong positive association between them i.e. more time spent sitting at the workplace the more likely he/she will have higher BMI/overweight. Our result shows similarity with the finding of with finding of Mummery W, et al. of 69.8 % for workers with a daily sitting time of >6hrs [6]. The increased risk of overweight associated with sedentary behaviour can be attributed to the reduced metabolism rate while sitting as compared to physical workout/standing. Further Sameer H AlGhamdi found that children who spent more time watching television have a higher risk of being obese [4]. Bak H, et al. found that there is no significant impact of occupational sitting time with obesity and rather bodyweight is a strong predictor to time spent in physical activity [7]. Our result also shows that continuous sitting time has not much significant association with overweight. Also, as our result yielded an R square value of 0.537 which indicates that there is significant variation in overweight which is not attributed by sitting time. These is in line with the previous finding that the risk of overweight depended on genetic makeup and lifestyle factor such as dietary intakes, cultural and social environment. M Scharoun-Lee, et al. noted that the risk of obesity is higher in the case of historically underprivileged ethnic/racial minorities [18]. We, therefore, reject our null hypothesis that "there is no association between sitting time and overweight", thus there is a strong positive significant association between daily sitting time and overweight. We further recommend in line with the previous finding that workplace sitting time should be minimized and that arrangement should be provided so that users can effectively work without loss of productivity [19].

The correlation coefficient for continuous sitting time and prevalence of various MSD shows that the association between them range from mild to strong. The association is strongest with Hip/Buttock pain of 0.771 correlation coefficient indicating that sitting for a longer period of time will result in the development of hi/buttock pain. Our result is in line with the previous finding that prolonged sitting leads to the development of MSD in user [20]. Fenety and Walker noted that the development of MSD is due to continuous static loading on various body parts and recommend intermittent changes in postures [21]. Gallagher, et al. noted that continuous loading for 45 min is sufficient for onsets of MSD in users [22]. It may be noted here that our results yielded the lowest correlation between neck stiffness and sitting time while Moom, et al. found that among computer users of bank employee it is predominantly prevalence after Back pain [9]. The difference in result maybe explains by the adoption of an adjustable monitor angle which promotes changes in neck posture. We, therefore, reject our null hypothesis that "Continuous sitting time has no association with prevalence of MSD", thus from our study, we conclude "There is a varying association between continuous sitting time and prevalence of various MSD".

The correlation coefficient shows that there is a significant negative association between users perceived comforts (-0.883) and productivity (-0.682) with continuous sitting time. However, there is a mild association between daily sitting time and perceived comforts (-0.385) and productivity (-0.288). The result is as expected from the previous finding that prolonged sitting leads to the development of MSD

which leads to discomforts and ultimately leading to reduced productivity. Users may forcibly sit for prolonged periods in the workplace due to organizational/business setups which impact their perception of the workplace. Skyberg, et al. noted that users perceived control over their setup affect the satisfaction level of workers [23]. Further, the correlation of prevalence of fatigue/headaches with continuous sitting time yielded a coefficient of 0.770 which is in agreement with the previous finding of McCrady and Levine where they found that physically active workers are less vulnerable to stress [24]. Also, Thorp, et al. found that users reported lesser fatigue while using sit-stand workstation [25]. Further, our results have been corroborated by the finding of Gourab Kar and Alan Hedge that there is a significant reduction in short term typing error in standing workstation without significant reduction in speed [26]. We, therefore, reject our null hypothesis that "There is no significant association between sitting time and perceived comforts and productivity". Thus, there is a significant negative association between continuous sitting time and users perceived comforts and productivity.

The result of correlation shows that there is a varying degree of association between various discomforts and different workstation setups. Our result is in line with the previous finding that different work setup affects different parts of users. Studies have shown that the specific placement of workstation affects different parts of the upper body [27]. Back pain is found to be mostly associated with the adjustability of the reclining chair which maybe explain as the ability of users to afford more range of motion with respect to spine motion. Studies have shown that the continuous change in the posture of the spine will enhance the flow of nutrition in the vertebral disc [28]. The association between shoulder pain and adjustability of chair back support could be attributed to the location of the support for shoulders while reclining on a chair. From the result we find that there is a strong association between Hip/buttock pain and adjustability of monitor angles and Tables height, the latter could be attributed with the ability to intermittently stand and work. The association between adjustability of monitor angles and hip/buttock pain could be mere coincidence and need further investigation. Further our results corroborate the finding of Young, et al. that viewing angles of computer monitors affect neck posture and its comfort levels [29]. The low association of eyes strain with the above different setups may be due to the fact that eye strain is majorly due to the difference in intensity of the light source and also users may maintain a constant distance of viewing despite the changes in workstation setups. However, it may be noted that the majority of user i.e. 68.45% reported of occurrence of eyes strain. Also, correlation coefficient i.e. 0.646 shows that prolonged continuous viewing of the computer screen is detrimental eyes and lead to eyes strain in users.

The strength of this study is that through a simple self-reported questionnaire feedback form we are able to understand the various impact of computer workstation on users. However, the strength and result of this study should be view along with its limitation such as the inherent bias of respondent, limited parameter under consideration as various other office ergonomics like room temperature, amount of workload, illumination, noise level etc. can affect the comforts and productivity of workers. Future work could incorporate a larger sample size of the respondent for the study along with more parameters such as weekend leisure time activity, foods habits and other office dynamics. Also, a comparison study between the adjustable sit-stand workstation and sitting workstation could be undertaken. Further a quantitative measurement of productivity such as average words types etc. could be used to remove subjectivity and bias in reports.

Conclusion

In conclusion, we would recommend a reduction in prolonged sitting and daily sitting time through the addition of intermittent breaks and a means to work while standing. Majority of users reported that back pain starts developing between 1:00-1:30 hours, we therefore strongly advised against continuous static posture for more than 1 hours. We recommend that organizational and personal ergonomic training should be inculcated for reaping greater health and productivity benefits in tandem with previous studies [5]. Furthermore, the majority of user i.e. 87.45% reported they would prefer adjustable workstation over fixed workstation. In addition to the reduction of sitting time and adoption of adjustable workstation, we would recommend that care and emphasis should be taken so that the prevalence of eye strain should be minimized. The study results provided insights on the various impact of computer workstation on users and also act as a guide for the proper design of a computer workplace.

References

1. Van Uffelen JGZ (2010) Occupational sitting and health risks: A systematic review. Am J Prev Med 39(4): 379-388.

2. Jakicic JM (2012) Physical activity and weight loss. Nestle Nutr Inst Workshop Ser 73: 21-36.

3. Dunstan DW, Healy GN, Sugiyama T, Owen N (2009) Too much sitting and metabolic risk-Has modern technology caught up with us? US Endocrinol 5: 29-33.

4. https://www.touchendocrinology.com/diabetes/journal-articles/too-much-sitting-and-metabolic-risk-has-modern-technology-caught-up-with-us/

5. Al Ghamdi S (2013) The association between watching television and obesity in children of school-age in Saudi Arabia. J Fam Community Med 20(2): 83-89.

6. Healy GN (2008) Objectively measured sedentary time, physical activity, and metabolic risk. Diabetes Care 31(2): 369-371.

7. Mummery WK, Schofield GM, Steele R, Eakin EG, Brown WJ (2005) Occupational sitting time and overweight and obesity in Australian workers. Am J Prev Med 29(2): 91-97.

8. Bak H, Petersen L, Sørensen TIA (2004) Physical activity in relation to development and maintenance of obesity in men with and without juvenile onset obesity. Int J Obes 28(1): 99-104.

9. Shariat A, Cleland JA, Danaee M, Kargarfard M, Sangelaji B, et al. (2018) Effects of stretching exercise training and ergonomic modifications on musculoskeletal discomforts of office workers: a randomized controlled trial. Brazilian J Phys Ther 22(2): 144-153.

10. Moom RK, Sing LP, Moom N (2015) Prevalence of Musculoskeletal Disorder among Computer Bank Office Employees in Punjab (India): A Case Study. Procedia Manuf 3: 6624-6631.

11. James C (2018) Musculoskeletal discomfort and use of computers in the university environment. Appl Ergon 69: 128-135.

12. Lin MY, Barbir A, Dennerlein JT (2017) Evaluating biomechanics of user-selected sitting and standing computer workstation. Appl Ergon 65: 382-388.

13. Wennberg P (2016) Acute effects of breaking up prolonged sitting on fatigue and cognition: A pilot study. BMJ Open 6(2): e009630.

14. Alkhajah TA, Reeves MM, Eakin EG, Winkler EAH, Owen N (2012) Sit-stand workstations: A pilot intervention to reduce office sitting time. Am J Prev Med 43(3): 298-303.

15. Hall J, Mansfield L, Kay T, McConnell AK (2015) The effect of a sit-stand workstation intervention on daily sitting, standing and physical activity: Protocol for a 12 month workplace randomised control trial. BMC Public Health 15(1): 1-9.

16. Proper KI, Cerin E, Brown WJ, Owen N (2007) Sitting time and socio-economic differences in overweight and obesity. Int J Obes 31(1): 169-176.

17. Lin MY, Catalano P, Chan HTH, Health P, Dennerlein JT (2016) A Psychophysical Protocol to Develop Ergonomic Recommendations for Sitting and Standing Workstations. Hum Factors Ergon Soc 58(4): 574-585.

18. Kingma I, van Dieën JH (2009) Static and dynamic postural loadings during computer work in females: Sitting on an office chair versus sitting on an exercise ball. Appl Ergon 40(2): 199-205.

19. Scharoun Lee M, Kaufman JS, Popkin BM, Gordon Larsen P (2009) Obesity, race/ethnicity and life course socioeconomic status across the transition from adolescence to adulthood. J Epidemiol Community Health 63(2): 133-139.

20. Hedge A, Ray EJ (2004) Effects of an Electronic Height-Adjustable Worksurface on Computer Worker Musculoskeletal Discomfort and Productivity. Proc Hum Factors Ergon Soc Annu Meet 48(8): 1091-1095.

21. Gupta N, Christiansen CS, Hallman DM, Korshøj M, Carneiro IG, et al. (2015) Is objectively measured sitting time associated with low back pain? A cross-sectional investigation in the NOMAD study. PLoS One 10(3): 1-18.

22. Fenety A, Walker JM (2017) Short-Term Effects of Workstation Exercises on Musculoskeletal Discomfort and Postural Changes in Seated Video Display Unit Workers. Phys Ther 82(6): 578-589.

23. Gallagher KM, Campbell T, Callaghan JP (2014) The influence of a seated break on prolonged standing induced low back pain development. Ergonomics 57(4): 555-562.

24. Skyberg K, Skulberg KR, Eduard W, Skåret E, Levy F, et al. (2009) Symptoms prevalence among office employees and associations to building characteristics. Indoor Air 13(3): 246-252.

25. McCrady SK, Levine JA (2009) Sedentariness at work: How much do we really sit?. Obesity 17(11): 2103-2105.

26. Thorp AA (2012) Prolonged sedentary time and physical activity in workplace and non-work contexts. Int J Behav Nutr Phys Act 9(1): 128.

27. Kar G, Hedge A (2016) Effects of Sitting and Standing Work Postures on Short-Term Typing Performance and Discomfort. Proceedings of the Human Factors and Ergonomics Society Annual Meeting 60(1): 460-464.

28. Ankrum D, Fraser K, Plooy A, Burgess Limerick R (1999) The influence of computer monitor height on head and neck posture. Int J Ind Ergon 23(3): 171-179.

29. Van Deursen LL, Patijn J, Durinck JR, Brouwer R, Van Erven Sommers JR, et al. (1999) Sitting and low back

pain: The positive effect of rotatory dynamic stimuli during prolonged sitting. Eur Spine J 8(3): 187-193.

30. Young JG, Trudeau MB, Odell D, Marinelli K, Dennerlein JT (2013) Wrist and shoulder posture and muscle activity during touch-screen tablet use: Effects of usage configuration, tablet type, and interacting hand. Work 45(1): 59-71.