Assignment Title: ‘The Efficacy of Sit-to-Stand Workstations for Work-Related Musculoskeletal Disorders and Improved Health Outcomes’

Introduction

Technological advances are resulting in more work becoming sedentary, seated, and office-based. Office workers in Australia have demonstrated high levels of sitting both at work and in leisure time on workdays and non-work days, with as much as 77% of the average work day spent setting, and often accrued in prolonged unbroken bouts (Parry, 2013; Smith et al., 2015). The effects of sitting at work are multifaceted with a combination of metabolic, cardiovascular, and musculoskeletal health impacts regardless of whether one meets recommended levels of physical activity during leisure (Chau et al., 2014; Li et al., 2017; Shrestha, Ijaz, Kukkonen-Harjula, Kumar, & Nwankwo, 2015). Increased sitting time has been correlated with increased risk of premature chronic disease and mortality and increased work-related musculoskeletal disorders (Chau et al., 2013).

Work-related musculoskeletal disorders (WMSDs) is a term used to describe painful disorders affecting all parts of the body. WMSDs often result in sick leave, work disability and early retirement, placing a large burden on working society. WMSDs are thought to be more common in occupations involving static low loads and repetitive actions, two characteristics of office work. WMSDs in this environment are thought to be due to the lack of movement in sitting reducing the robustness of the tissue as a consequence of decreased tissue tolerances, induced passive loading on to the spine and the microdamage of sustained loading (Le & Marras, 2016). According to several studies WMSDs are positively associated with consecutive hours of computer work, reduced frequency of rest breaks during computer work, a long duration of sustained posture during computer work, computer usage of more than 15 years and a lack of ergonomic knowledge.

Literature shows that there has been an increase in frequency of WMSDs with the development of computer technology, most commonly in the neck, upper limb and back across the developed and developing world (Mani, Provident, & Eckel, 2016). Griffiths, Mackey, Adamson, and Pepper (2012) estimate the prevalence of neck, shoulder and back pain within the office population as 67%, 71% and 66% respectively. Low back pain (LBP) is the greatest contributor to global disability (developed and developing countries) with the greatest burden occurring in middle age (Buchbinder et al., 2013). In 2014-15, one in six Australians had chronic LBP (CLBP), with 77% of the working age CLBP population experiencing a restriction in employment as a consequence (Australian Government Institute of Health & Welfare, 2016). In addition office-workers have the highest incidence of neck disorders among all occupations at 17% to 21% (Shahidi, Curran-Everett, & Maluf, 2015; Sihawong, Sitthipornvorakul, Paksaichol, & Janwantanakul, 2014; cited in Chen et al., 2018) and a significant rate of recurrence with approximately 34% to 49% of workers reporting a new onset of neck pain within 1-year (Cote et al., 2008; Hush et al., 2009; Sihawong et al., 2014; Korhonen et al., 2003; cited in Chen et al., 2018). Therefore the importance of preventing these WMSDs is critical to improving community health outcomes, disease and mortality prevalence.

The evidence that prolonged sitting in the workplace results in increased rates of chronic disease, premature mortality and WMSDs, together with evidence that prolonged sitting during work hours is not offset by physical activity outside of work hours, has led to the development of approaches within the workplace to reduce sedentary behaviour such as prolonged sitting (Mainsbridge, Cooley, Fraser, & Pedersen, 2014 cited in Bantoft et al., 2016). Many proposed ergonomic strategies to create physical variation in office workers including ergonomic training, job rotation, active break-times and workstation modification have been reported throughout the literature. Specifically sit-stand workstations (SSWs) are seen by many as a workstation modification intervention providing physical variance to work postures and therefore may be able to reduce WMSDs and also increase energy expenditure (Karakolis, Barrett, & Callaghan, 2016). This paper provides a review of the available literature to determine the efficacy of ergonomic workstation modification, via SSWs, for preventing WMSDs and improving the health of office workers.

Findings

The research to date assessing SSWs is limited by methodological quality and therefore findings must be interpreted with caution. Two systematic reviews were found for the effects of SSWs in an office population. Tew, Posso, Arundel, and McDaid (2015) found methodological shortcomings in most SSW studies to date and hence concluded that there remains considerable uncertainty regarding the magnitude of their effects on workplace sitting time, health-related and work-productivity outcomes. Shrestha et al. (2015) concluded in their Cochrane review that it remains unclear if standing can repair the cardio-metabolic harms of sitting because there is minimal additional energy expenditure. Additionally Shrestha et al. (2015) concluded that SSW did not have a considerable effect on work performance, musculoskeletal symptoms or sick leave. They stated that the reviewed evidence was of a very-low to low quality for short-to-medium term reductions in sitting time without adverse effects on musculoskeletal symptoms or work productivity and no evidence in the long-term.

Since then several studies utilising randomised controlled intervention studies have attempted to gain further evidence on WMSDs with SSWs. Unfortunately they too have significant methodological weaknesses including a failure to blind subjects, therapists and assessors and objectively measure standing and sitting times. In addition the premise that increased standing time was beneficial has been challenged by research highlighting the presence of musculoskeletal symptoms with prolonged standing.

Coenen et al. (2017) in a two-arm cluster randomized control trial (n=201) concluded that SSWs were generally effective in reducing sitting and increasing standing with the effects greater in asymptomatic subjects than symptomatic LBP subjects. This suggests SSWs may be useful for both populations but more so those without pain, thereby providing a preventative, health protecting intervention. Unfortunately, it is difficult to determine whether their findings were a consequence of back pain influencing the sitting time or whether sitting interventions influenced the presence or severity of the symptoms given workstation position and schedule of postural change were self-selected.

The results of Coenen et al. (2017) were also supported by a number of other studies. Gao, Nevala, Cronin, and Finni (2016) in a controlled intervention study (n=45) found improvements in perceived musculoskeletal comfort in the neck, shoulders, and lower limbs with an improvement in back comfort associated with reduced sitting time. The study was performed with the intervention over six months in a real-world office setting without prompting postural changes adding strength to the findings. However the objective recording of measures for sitting time or musculoskeletal discomfort scores were made retrospectively via questionnaire introducing the risk of recall bias to the results.

Gao, Nevala, et al. (2016) findings were largely supported by Danquah, Kloster, Holtermann, Aadahl, and Tolstrup (2017) who found a positive relationship between sitting time and the prevalence of neck-shoulder pain but not lower back pain suggesting that it is quite acceptable to replace sitting with standing for back or lower extremity pain. This large RCT study (n=317) across 19 different office settings, utilized quantitative measures of sitting and standing time however the method of pain measurement lacked sensitivity to change and the intervention was multi-component. Therefore whilst the outcome measures of discomfort remain true and related to standing time increases, it is difficult to determine the extent of the effect generated from the SSWs.

The benefit of standing prolonged was questioned by Lin, Barbir, and Dennerlein (2017) who found that standing workstation use was associated with overall discomfort scores twice that of sitting after 45 minutes, with the most discomfort in the lower back when standing, and shoulder when sitting. This was in support of Andersen, Haahr, and Frost (2007) who found that LBP was generated by prolonged standing of more than 30 minutes per hour in asymptomatic workers. Therefore it appears that schedules involving prolonged standing of greater than 30 minutes are not the answer for WMSDs prevention and hence some of the findings associated with SSWs outcomes throughout the research may be confounded by the scheduling (durations and frequencies) of sitting and standing.

In studies looking at scheduling in asymptomatic subjects Gallagher, Campbell, and Callaghan (2014) and Karakolis et al. (2016) found that a schedule of three-to-one was insufficient to allow lasting recovery of LBP generated in standing when accumulated through a working day. Gallagher et al. (2014) and Karakolis et al. (2016) used the same ratio with different cycle times (60 minutes and 20 minutes respectively) yet yielded similar results suggesting that the total time accumulated standing in a day may be relevant regardless of the cycle time. Karakolis et al. (2016) findings indicated SSW injury prevention benefits were likely due to limited total exposure time to static positions rather than reduced lumbar spine compressive loading. Interestingly, Thorp, Kingwell, Owen, and Dunstan (2014) found that a 30-minute rotating schedule of SSWs use can reduce fatigue and discomfort in the lower back compared with a sitting only workstation but there results may only be generalized to a population of overweight or obese adults. Furthermore, Bao and Lin (2018) found that schedules ranging from one-to-one to seven-to-one made no difference to perceived back pain, shoulder muscle fatigue, spinal shrinkage or foot swelling but a one-to-one or three-to-one sit-stand schedule was preferred by workers while a seven-to-one schedule was least preferred. Bao and Lin (2018) used a repeated measures design with a failure to compare with a control only sitting group whilst only using a very small sample (n=12) hence the significance of their results are questionable. Therefore results of scheduling for SSWs use and WMSDs prevention are not yet supported by the research for LBP and indicate the need to change positions often to alleviate musculoskeletal pain or discomfort generated by static postures.

One of the proposed reasons for LBP with seated office-work is thought to be due to spinal shrinkage mediated effects. Interestingly though, Gao, Cronin, Pesola, and Finni (2016) cross-sectional study of a similar sample size (n= 24) found SSWs use had no effect on spinal shrinkage and hence spinal shrinkage was unlikely related to self-reported improvements in musculoskeletal discomfort. This supports the results of Bao and Lin (2018). It would therefore appear that SSWs results in a non-significant change to spinal shrinkage and is unlikely the reason for any differences that occur between sitting and standing postures.

In general, there remains limited research available to examine the effects of SSWs on neck pain in office workers. The mechanisms of computer work–related neck pain have been related to reductions in neck proprioception due to prolonged static work postures (Szeto, Chan, Chan, Lai, & Lau, 2014). Pronk, Katz, Lowry, and Payfer (2012) in a non-randomized interrupted time series study design demonstrated a 54% reduction in reports of upper back and neck pain during the use of a SSW over a four-week intervention period. These findings suggest that a SSW may be beneficial for reducing neck and shoulder discomfort but there remain several limitations with the study design and data collection methods that introduce a degree of bias.

In regards to other workstation adjustments for the prevention and reduction of neck pain, a systematic review by Chen et al. (2018) concluded that multiple workstation adjustments (keyboard angle, monitor angle, mouse placement) are effective in office workers who are symptomatic but there exists conflicting and low quality evidence for the general asymptomatic office population. The review failed to analyse the use of SSW for neck pain and recommended more high quality ergonomic RCT's are performed before firmer conclusions could be made. At present there remains a lack of evidence and therefore one cannot generalize these findings to the use of a SSW for the asymptomatic office worker and preventative purposes.

Neck static postures are evidenced by research comparing dual monitor desktop use to the use of a laptop computer. Farias Zuniga and Côté (2017) found the use of a dual monitor desktop computer reduced neck muscle activity and maintained more typical neck movement patterns compared with laptop use. Therefore it may be helpful to use a SSW with a dual monitor versus traditional monitor on a horizontal work surface to provide greater cervical motor variability and more neutral upper limb positioning thereby providing an injury-protective factor (Szeto et al., 2014) however no research into this area could be found.

Similarly, there also remains a lack of quality research into the effect of SSWs on upper extremity WMSDs. Van Eerd et al. (2016) in a systematic review into the effectiveness of workplace interventions for the prevention of upper extremity musculoskeletal disorders and symptoms, found moderate evidence for no benefit in office workstation adjustment and moderate evidence for a positive benefit for forearm supports for upper extremity WMSDs and symptoms.

Lin et al. (2017) in a repeated measures laboratory study found that standing workstation use was associated with more neutral shoulder postures and lower shoulder muscle activity but compensation occurred via greater wrist extension and forearm extensor muscle activity whilst remaining within the ergonomic guidelines. This was postulated to occur through user selected positioning in an attempt to distribute weight through their forearms to the desk as opposed to sitting where weight was distributed through the chair back support via a reclined sitting position. The results were obtained over short trial periods and hence it remains unknown whether the accumulated effects of non-neutral postures and sustained muscle activation increase upper extremity WMSDs in the longer-term. The combination of factors associated with keyboard and mouse positioning in standing positions of SSWs make it difficult to determine the relative contribution of SSWs use to WMSDs risk in the upper limb.

Earlier Ebara et al. (2008) found that alternating between sitting and standing may increase performance but this was associated with increased wrist discomfort compared with a sitting workstation. It was proposed that poor adjustment to keyboard and mouse pads to achieve optimal wrist position may have been causative given that the optimal wrist position varied between sitting and standing. However the research involved a small sample size and the sitting height for the sit only group varied from the sitting height for the sit-stand group thereby limiting the findings. Interestingly, Kar and Hedge (2016) also found that a standing work posture can improve performance by way of more accurate short-term computer typing, however their results contradicted those of Ebara et al. (2008) in that this improved task performance occurred with a reduction in upper body discomfort scores.

Aside from WMSDs, one of the proposed health benefits of SSWs is thought to be due to increased energy expenditure and improvements in cardio-metabolic parameters. However, the literature is inconclusive re the significance of change in energy expenditure and cardio-metabolic health attributable to SSW use. Burns, Forde, and Dockrell (2017) found that the task performed has a greater effect on energy expenditure than the posture the task was performed in and therefore substituting standing for sitting was not adequate to produce metabolic health benefits. The energy expenditure typically remained of a sedentary to light level (<1.5 MET's) with no change to moderate or vigorous activity levels. It is suggested that any increase in activity levels was a consequence of the movement from sitting to standing rather than the standing and hence it may be encouraged to promote more movement during a working day. It has also been suggested that a combination of interventions directed at increasing activity, for example short activity breaks and walking or stair climbing, would be more effective than the introduction of one factor alone (Healy et al., 2013; Mansoubi, Pearson, Biddle, & Clemes, 2016; Neuhaus, Healy, Dunstan, Owen, & Eakin, 2014).

In contrast, there are several studies reporting improvements in cardio-metabolic parameters such as improved glucose levels (Healy et al., 2013), total cholesterol reduction (Graves, Murphy, Shepherd, Cabot, & Hopkins, 2015), and increased HDL cholesterol (Alkhajah et al., 2012) with increased standing due to SSW use. Interestingly, Pesola et al. (2015) found that small increases in muscle activity from standing may improve metabolic markers independent of moderate to vigorous activity time. Gao, Cronin, et al. (2016) found no change to moderate-to-vigorous muscle activity levels but found a 15% reduction in muscle inactivity with a sit-stand group implying that this may have a benefit to cardio-metabolic factors. Additionally, an increase in standing during work shifts was shown to be effective for obese or overweight office workers in terms of metabolic outcomes (Thorp et al., 2014) however this intervention only lasted five days and contrasts with the findings of MacEwen, Saunders, MacDonald, and Burr (2017) who found 12 weeks of SSW use failed to change cardio-metabolic markers in office workers with abdominal obesity. Therefore the evidence for SSW's improving office workers health via increased energy expenditure and improved cardio-metabolic health is not conclusive.

Conclusion

Although SSWs are becoming popular for improving health and preventing WMSDs, their potential health benefits are very uncertain. The current evidence base would be improved with methodological consideration around larger samples, longer follow-up and improved data collection tools to improve study power and reduce risk of bias (Chau et al., 2014; Graves et al., 2015; Li et al., 2017). In general it appears that SSWs may reduce discomfort in the shoulders and upper back or neck when standing and the lower back and lower extremities when sitting. With respect to scheduling, the ability to avoid prolonged sitting or standing is perhaps the most important factor in reducing WMSDs. SSWs research indicates the movement between sitting and standing may be the most important factor for improving cardio-metabolic parameters and energy expenditure suggesting interventions requiring movement may be more effective than SSWs alone. It has been shown that a combination of interventions directed at increasing standing activity has been shown to be more effective than the introduction of one-factor alone, for example SSW implementation together with ergonomic training, but the effects on productivity and health outcomes must be interpreted in context with economic considerations over the longer-term. It is important that any recommendations of use for SSWs as short and long-term preventative tools for WMSD’s and cardio-metabolic parameters, are recognized in light of the limitations of the current evidence base.

References

Alkhajah, T. A., Reeves, M. M., Eakin, E. G., Winkler, E. A. H., Owen, N., & Healy, G. N. (2012). Sit-stand workstations: A pilot intervention to reduce office sitting time. *American Journal of Preventive Medicine, 43*(3), 298-303. doi:10.1016/j.amepre.2012.05.027

Andersen, J. H., Haahr, J. P., & Frost, P. (2007). Risk factors for more severe regional musculoskeletal symptoms: A two-year prospective study of a general working population. *Arthritis & Rheumatology, 56*(4), 1355-1364.

Australian Government Institute of Health and Welfare (August, 2016). *Impacts of Chronic Back Problems*. [Bulletin 137]. Retrieved from https://www.aihw.gov.au/getmedia/9018da61-cdf0-4e3a-bd98-2508f515290d/19839.pdf.aspx?inline=true

Bantoft, C., Summers, M. J., Tranent, P. J., Palmer, M. A., Cooley, P. D., & Pedersen, S. J. (2016). Effect of Standing or Walking at a Workstation on Cognitive Function: A Randomized Counterbalanced Trial. *Human Factors: The Journal of Human Factors and Ergonomics Society, 58*(1), 140-149. doi:10.1177/0018720815605446

Bao, S., & Lin, J.-H. (2018). An investigation into four different sit-stand workstation use schedules. *Ergonomics, 61*(2), 243. doi:10.1080/00140139.2017.1353139

Buchbinder, R., Blyth, F. M., March, L. M., Brooks, P., Woolf, A. D., & Hoy, D. G. (2013). Placing the global burden of low back pain in context. *Best Practice & Research Clinical Rheumatology, 27*(5), 575-589.

Burns, J., Forde, C., & Dockrell, S. (2017). Energy Expenditure of Standing Compared to Sitting While Conducting Office Tasks. *Human Factors: The Journal of Human*

Factors and Ergonomics Society, 59(7), 1078-1087. doi:10.1177/0018720817719167

Chau, J. Y., Daley, M., Srinivasan, A., Dunn, S., Bauman, A. E., & van der Ploeg, H. P. (2014). Desk-based workers' perspectives on using sit-stand workstations: a qualitative analysis of the Stand@Work study. *BMC Public Health, 14*(1), 752. doi:10.1186/1471-2458-14-752

Chau, J. Y., Grunseit, A. C., Chey, T., Stamatakis, E., Brown, W. J., Matthews, C. E., Bauman, A. E., & van der Ploeg, H. P. (2013). Daily sitting time and all-cause mortality: a meta-analysis. *Plos One, 8*(11), e80000. doi:10.1371/journal.pone.0080000

Chen, X., Coombes, B. K., Sjøgaard, G., Jun, D., O'Leary, S., & Johnston, V. (2018). Workplace-Based Interventions for Neck Pain in Office Workers: Systematic Review and Meta-Analysis. *Physical therapy, 98*(1), 40-62. doi:10.1093/ptj/pzx101

Coenen, P., Healy, G. N., Winkler, E. A., Dunstan, D. W., Owen, N., Moodie, M., LaMontagne, A.D., Eakin, E.A., & Straker, L. M. (2017). Pre-existing low-back symptoms impact adversely on sitting time reduction in office workers. *International Archives of Occupational and Environmental Health, 90*(7), 609-618.

Danquah, I. H., Kloster, S., Holtermann, A., Aadahl, M., & Tolstrup, J. S. (2017). Effects on musculoskeletal pain from "Take a Stand!" – a cluster-randomized controlled trial reducing sitting time among office workers. *Scandinavian journal of work, environment & health, 43*(4), 350. doi:10.5271/sjweh.3639

Ebara, T., Kubo, T., Inoue, T., Murasaki, G.-I., Takeyama, H., Sato, T., Suzumara, H., Niwa, S., Takanishi, T., Tachi, N., & Itani, T. (2008). Effects of Adjustable Sit-stand VDT Workstations on Workers' Musculoskeletal Discomfort, Alertness and Performance. *Industrial Health, 46*(5), 497-505. doi:10.2486/indhealth.46.497

Farias Zuniga, A. M., & Côté, J. N. (2017). Effects of Dual Monitor Computer Work Versus Laptop Work on Cervical Muscular and Proprioceptive Characteristics of Males and Females. *Human Factors: The Journal of Human Factors and Ergonomics Society, 59*(4), 546-563. doi:10.1177/0018720816684690

Gallagher, K. M., Campbell, T., & Callaghan, J. P. (2014). The influence of a seated break on prolonged standing induced low back pain development. *Ergonomics, 57*(4), 555-562.

Gao, Y., Cronin, N. J., Pesola, A. J., & Finni, T. (2016). Muscle activity patterns and spinal shrinkage in office workers using a sit-stand workstation versus a sit workstation. *Ergonomics, 59*(10), 1267-1274. doi:10.1080/00140139.2016.1139750

Gao, Y., Nevala, N., Cronin, N. J., & Finni, T. (2016). Effects of environmental intervention on sedentary time, musculoskeletal comfort and work ability in office workers. *European Journal of Sport Science, 16*(6), 747-754. doi:10.1080/17461391.2015.1106590

Graves, L. E. F., Murphy, R. C., Shepherd, S. O., Cabot, J., & Hopkins, N. D. (2015). Evaluation of sit-stand workstations in an office setting: a randomised controlled trial. *BMC Public Health, 15*(1), 1145. doi:10.1186/s12889-015-2469-8

Griffiths, K. L., Mackey, M. G., Adamson, B. J., & Pepper, K. L. (2012). Prevalence and risk factors for musculoskeletal symptoms with computer based work across occupations. *Work (Reading, Mass.), 42*(4), 533-541.

Healy, G. N., Eakin, E. G., LaMontagne, A. D., Owen, N., Winkler, E. A. H., Wiesner, G., Gunning, L., Neuhaus, M., Lawler, S., Fjeldsoe, B. S., & Dunstan, D. W. (2013). Reducing sitting time in office workers: Short-term efficacy of a multicomponent intervention. *Preventive Medicine, 57*(1), 43-48. doi:10.1016/j.ypmed.2013.04.004

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. doi:10.1177/1541931213601104

Karakolis, T., Barrett, J., & Callaghan, J. P. (2016). A comparison of trunk biomechanics, musculoskeletal discomfort and productivity during simulated sit-stand office work. *Ergonomics, 59*(10), 1275-1287. doi:10.1080/00140139.2016.1146343

Le, P., & Marras, W. S. (2016). Evaluating the low back biomechanics of three different office workstations: Seated, standing, and perching. *Applied Ergonomics, 56*, 170-178. doi:10.1016/j.apergo.2016.04.001

Li, I., Mackey, M. G., Foley, B., Pappas, E., Edwards, K., Chau, J. Y., Engelen, L., Voukelatos, A., Whelan,A., Bauman, A., Winkler, E., & Stamatakis, E. (2017). Reducing Office Workers' Sitting Time at Work Using Sit-Stand Protocols: Results From a Pilot Randomized Controlled Trial. *Journal of Occupational and Environmental Medicine, 59*(6), 543-549. doi:10.1097/JOM.0000000000001018

Lin, M. Y., Barbir, A., & Dennerlein, J. T. (2017). Evaluating biomechanics of user-selected sitting and standing computer workstation. *Applied Ergonomics, 65*, 382-388. doi:10.1016/j.apergo.2017.04.006

MacEwen, B. T., Saunders, T. J., MacDonald, D. J., & Burr, J. F. (2017). Sit-Stand Desks To Reduce Workplace Sitting Time In Office Workers With Abdominal Obesity: A Randomized Controlled Trial. *Journal Of Physical Activity & Health, 14*(9), 710-715. doi:10.1123/jpah.2016-0384

Mani, K., Provident, I., & Eckel, E. (2016). Evidence-based ergonomics education:Promoting risk factor awareness among office computer workers. *Work- A Journal of Prvention Assessment & Rehabilitation, 55*(4), 913-922. doi:10.3233/WOR-162457

Mansoubi, M., Pearson, N., Biddle, S. J. H., & Clemes, S. A. (2016). Using Sit-to-Stand Workstations in Offices: Is There a Compensation Effect? *Medicine & Science in Sports & Exercise, 48*(4), 720-725. doi:10.1249/MSS.0000000000000802

Neuhaus, M., Healy, G. N., Dunstan, D. W., Owen, N., & Eakin, E. G. (2014). Workplace Sitting and Height-Adjustable Workstations A Randomized Controlled Trial. *American Journal of Preventive Medicine, 46*(1), 30-40. doi:10.1016/j.amepre.2013.09.009

Parry, S. S., L. (2013). The contribution of office work to sedentary behaviour associated risk. *BMC Public Health, 2013*(13), 10.

Pesola, A. J., Laukkanen, A., Tikkanen, O., SipilÄ, S., Kainulainen, H., & Finni, T. (2015). Muscle Inactivity Is Adversely Associated with Biomarkers in Physically Active Adults. *Medicine & Science in Sports & Exercise, 47*(6), 1188-1196. doi:10.1249/MSS.0000000000000527

Pronk, N. P., Katz, A. S., Lowry, M., & Payfer, J. R. (2012). Reducing occupational sitting time and improving worker health: the Take-a-Stand Project, 2011. *Preventing Chronic Disease, 9*, E154-E154. doi:10.5888.pcd9.110323

Shrestha, N., Ijaz, S., Kukkonen-Harjula, K. T., Kumar, S., & Nwankwo, C. P. (2015). Workplace interventions for reducing sitting at work. *Cochrane Database of Systematic Reviews, 1*(1), CD010912. doi:10.1002/14651858.CD010912.pub2

Smith, L., Hamer, M., Ucci, M., Marmot, A., Gardner, B., Sawyer, A., Wardle, J., & Fisher, A. (2015). Weekday and weekend patterns of objectively measured sitting, standing, and stepping in a sample of office-based workers: the active buildings study. *BMC Public Health, 15*(1), 9-9. doi:10.1186/s12889-014-1338-1

Szeto, G. P. Y., Chan, C. C. Y., Chan, S. K. M., Lai, H. Y., & Lau, E. P. Y. (2014). The effects of using a single display screen versus dual screens on neck-shoulder muscle activity during computer tasks. *International Journal of Industrial Ergonomics, 44*(3), 460-465. doi:10.1016/j.ergon.2014.01.003

Tew, G. A., Posso, M. C., Arundel, C. E., & McDaid, C. M. (2015). Systematic review: height-adjustable workstations to reduce sedentary behaviour in office-based workers. *Occupational Medicine-Oxford, 65*(5), 357-366. doi:10.1093/occmed/kqv044

Thorp, A. A., Kingwell, B. A., Owen, N., & Dunstan, D. W. (2014). Breaking up workplace sitting time with intermittent standing bouts improves fatigue and musculoskeletal discomfort in overweight/obese office workers. *Occup Environ Med, 71*(11), 765-771. doi:10.1136/oemed-2014-102348

Van Eerd, D., Munhall, C., Irvin, E., Rempel, D., Brewer, S., Van der Beek, A. J., Dennerlein, J. T., Tullar, J., Skivington, K., Pinion, C., & Amick, B. (2016). Effectiveness of workplace interventions in the prevention of upper extremity musculoskeletal disorders and symptoms: an update of the evidence. *Occupational and Environmental Medicine, 73*(1), 62-70. doi:10.1136/oemed-2015-102992