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Do Sit-Stand Workstations Increase Variation in Upper Arm Postures While Performing Computer-Intensive Office Work?

Divya Srinivasan[1], Svend Erik Mathiassen[2], Dechristian Barbieri[3] and Ana Beatriz Oliveira[3]

[1]Department of Industrial and Systems Engineering, Virginia Polytechnic Institute and State University, Blacksburg, USA

[2]Center for Musculoskeletal Research, Department of Occupational and Public Health Sciences, University of Gavle, Sweden

[3]Department of Physical Therapy, Federal University of São Carlos, São Paulo, Brazil

Corresponding author's Email: sdivya1@vt.edu

Author Note: Dr Divya Srinivasan is an Assistant Professor in the Department of Industrial & Systems Engineering, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA. Divya received her Doctorate in Biomedical Engineering from the University of Michigan, Ann Arbor, USA.

Extended Abstract: A recent systematic review of workplace interventions to reduce upper extremity musculoskeletal disorders among computer users, published in 2016, has concluded that there is limited evidence for any ergonomic intervention to have had strong effects on musculoskeletal outcomes. Static postures of the upper arms and hands, static muscle loads in the upper trapezius, and high repetitiveness of upper extremity movements while performing keyboard work are believed to be the key physical risk factors associated with upper extremity musculoskeletal symptoms. In this context, epidemiological studies have suggested that "more variation" in postures, movements and muscle loads are associated with lower risks of musculoskeletal disorders. How such variation may be practically obtained in office work is still an open question.

While sit-stand desks are often considered as a potential intervention to reduce the cardiovascular health risks associated with prolonged sitting, seated vs. standing computer work also place different biomechanical demands on the body. The objective of this study was to quantify the extent of "variation" in upper arm postures that can be obtained based on combining seated and standing computer work. Since the average upper arm postures are different between sitting and standing, can computer-intensive office work be made more variable (and hence possibly less risky) by combining seated and standing work? If yes, what proportion of sitting vs. standing computer work would yield the highest variation in upper arm postures?

Methods: These questions were examined by first recording average levels and minute-to-minute variance in upper arm elevation angle for 2 hours each, on 3 different days, from 24 users of sit-stand workstations when they performed their routine computer-based office work in their regular work environment. These data were synchronized with recordings of whether the user was sitting or standing to give data on arm elevation specifically in sitting and standing. Then, overall variation in upper arm posture was estimated in "jobs" comprised of different proportions of seated and standing computer work by numerical simulation, using the following equation to estimate exposure variance s_j^2, in the whole job:

$$s_j^2 = \sum_t W_t \left[(m_t - \sum_t W_t m_t)^2 + s_t^2 \right]$$

where W_t is the time proportion in the job of task t, m_t and s_t^2 are the mean exposure and minute to minute exposure variance of upper arm angle in task t, and Σ_t indicates summation across tasks included in the job (note that 2 tasks i.e. CW-sit and CW-stand are considered in this study). The simulated value of s_j^2 was then used to calculate the "job variance ratio" (JVR) of the simulated job using the following equation: $\text{JVR} = \frac{s_j^2}{s_{CW-sit}^2}$; where $s_j^2$is the minute-to-minute exposure variance of upper arm angle in the whole job and s_{CW-sit}^2 is the value of minute-to-minute exposure variance in upper arm angle during seated computer work for that participant. These equations were used to find what the maximum extent of variation obtainable in office work would be by combining seated and standing computer work performed at sit-stand workstations. For that purpose, we determined, for each participant, exposure variation in a hypothetical scenarios where the proportion of time in the job that had to be devoted to computer work in sitting vs. standing positions could be varied. Variable time proportions of CW-sit and CW-stand, ranging from 0 to 1 in increments of 0.01 were considered in numerical simulations. For each of these simulated task combinations (i.e. virtual "job"), the exposure variance, s_j^2, and JVR were computed. The "best possible" task combination, i.e. the one yielding the largest possible JVR, was then identified and reported in terms of the proportions of seated vs. standing computer work.

Results: For each of the 24 participants, figure 1 illustrates the results of the numerical simulations in terms of the proportions of time for computer work in sitting and standing positions that would yield the largest variation in upper arm angle during a whole day of computer work.

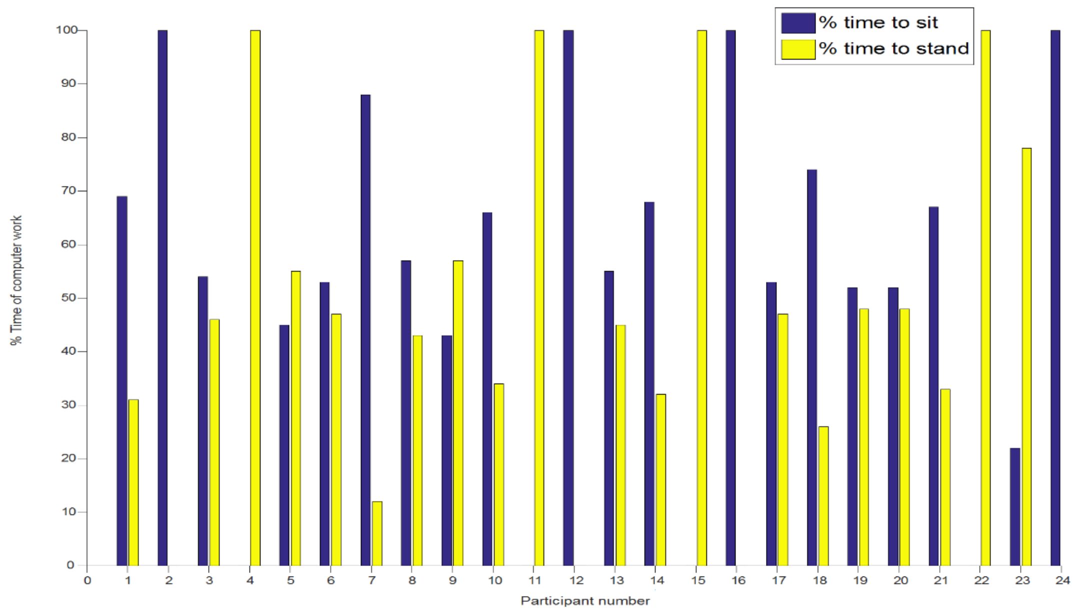

Figure 1 : Simulated proportions of computer work time to be spent in sitting vs. standing positions to obtain maximum variation in upper arm postures

For these simulated jobs, the maximum variation obtained for each subject in terms of JVR ranged from 1.0 (i.e. no improvement from sitting-only computer work) to 4.2. While 15 of 24 subjects showed JVRs in the range of 1 to 1.5, the remaining 9 subjects showed dramatic improvements in JVR of between 2 to 4.2. Five subjects showed no improvement in JVR when going from sitting-only computer work to a combination of sitting and standing computer work.

Discussion & Conclusion: Numerical simulations were performed using data collected from routine office work performed at sit-stand workstations. Our numerical simulations showed that the effect of sit-stand desks on upper arm postural variation during computer work is quite dependent on the individual. For most individuals, combinations of sitting and standing work presented an increase in upper arm postural variation during computer work compared to working only sitting. From this perspective, our results suggested that for most individuals, standing between 30 to 50% of computer work time would produce the largest variation in upper arm postures. Thus, implementing sit-stand work stations may be beneficial not only for cardiovascular health risks, but even in the context of musculoskeletal disorders.

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