

The effects of psychosocial factors on trapezius muscle activity levels during computer use.

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ABSTRACT The goal of the present study, a part of the PROOF (Predicting Occupational biomechanics among Office workers) study, was to determine if there was a relationship between psychosocial stress, measured by reward and over-commitment, and trapezius muscle activity while workers performed their own computer work in the field. We observed that workers reporting higher levels of over-commitment and lower reward also experienced approximately 40% higher median trapezius muscle activity levels than workers reporting lower levels of over-commitment and lower reward (change from 3.5% MVC to 6% MVC), with no difference in muscle activity for workers reporting high reward and either low or high over-commitment. Workers reporting higher levels of over-commitment experienced more variability in trapezius muscle activity. The results of this study may be used to inform interventions targeting reduction of musculoskeletal disorders among office workers.

INTRODUCTION

Musculoskeletal symptoms of the neck and shoulder regions are a major problem, especially for office workers who use the computer as a primary part of their work. The one-year prevalence of shoulder and neck symptoms among office workers has been estimated to be between 24% and 44% based on several large-scale studies (Jensen 2003, Juul-Kristensen et al. 2004). Psychosocial factors may contribute to the development of musculoskeletal symptoms and disorders among office workers (Bongers et al. 1993, 2006).

Some theoretical models have proposed that trapezius muscle activity may be a mediating factor on the pathway between psychosocial stress and musculoskeletal symptoms of the neck and shoulder regions (NRC/IOM 2001, Feuerstein 1996). While there is evidence to indicate that laboratory-induced stressors increase trapezius muscle activity levels (Rietveld et al. 2007; Wang et al. 2011), this relationship has not been investigated in the field where the stressors are realistic psychosocial factors.

The goal of this study was to investigate whether there is a relationship between

psychosocial stress and trapezius muscle activity during computer use among workers in different self-reported psychosocial environments measured by reward and over-commitment. We expected that participants experiencing more psychosocial stress would also experience higher levels of trapezius muscle activity during computer use.

METHODS

The 120 (34 male and 86 female) participants recruited for this study ranged in age from 23 to 63 (mean=40 years) and worked at least 20 hours a week at the VU University or the VU University Medical Center, both in Amsterdam, The Netherlands. The participants were all free from musculoskeletal symptoms at the time of the measurement. This project was approved by the applicable Institutional Review Boards for protection of human subjects.

The final 120 participants were recruited into the study population based on their psychosocial stress profiles. Over an eight month period, departments within the University were contacted to identify those that would be willing to participate in the study. All workers from interested departments were then contacted through flyers, emails, and in-person announcements requesting them to complete a short online survey determining their over-commitment via a 6-question scale and reward via a 11-question scale (Siegrist et al. 2004). Based on this data, workers within each department who were willing to participate in the study and fit the inclusion criteria were classified into tertiles for both the reward and over-commitment scales. The inclusion criteria were: worked more than 20 hours per week, free of musculoskeletal pain the week prior to measurement, could work the mouse with their right hand during the measurement period, and could use a desktop computer during the measurement period. Recruitment within each department aimed to balance age and gender across psychosocial profiles to minimize potential confounding. Once recruited, a 3½ hour period (1.5 hours of setup and 2 hours of data collection) was scheduled with participants for a time representative of their normal computer work with minimal meetings.

During the two hour data collection muscle activity was measured for the right and left trapezius using surface electromyography and a wireless logger system (Mega WBA, Mega Electronics LTD, Kupio, Finland). After abrading the target areas of the skin and washing these areas with alcohol, twelve millimeter diameter Ambu Bluesensor N-00-S surface electrodes containing highly conductive wet gel were mounted over the muscles of interest with 20 millimeter interelectrode spacing in accordance with published guidelines for the surface EMG of the trapezius (Jensen et al. 1993). The wireless EMG pre-amplifier was attached to the two electrodes and a third ground electrode was placed over the acromion or clavicle. Data were recorded at 1000 samples per second after amplification (bandwidth of 10-500 Hz). The bipolar signal was converted to an EMG amplitude signal by smoothing its absolute value through a 3Hz second-order, zero phase, low-pass Butterworth filter. The signals were then down-sampled to 40 samples per second using a mean filtering procedure.

EMG data were normalized to each participant's maximum voluntary contractions (MVCs), collected while participants attempted to abduct their arms upwards against resistance applied by the experimenter. Each muscle's MVC was the highest 1-second average of the EMG amplitudes collected from the three measurements with approximately 1 minute of rest in between each MVC.

To identify periods where participants were performing computer activities, computer interaction monitoring software recorded the beginning and end times of keyboard and mouse events captured by either the Windows operating system or through an external USB tracker (Model 110b, Ellisys Inc., Geneva, Switzerland). Periods of computer activity were defined as any time within 30 seconds of activating a key on the keyboard, pressing the button on the mouse, or moving the mouse (Chang et al. 2008; Blangsted et al. 2004).

EMG data from these identified periods of computer activity were combined and the median (50th percentile) and variability (90th-10th percentiles) of trapezius muscle activity were calculated for each participant.

Unadjusted multivariate ANOVA (MANOVA) models tested the hypotheses that trapezius muscle activity median values and variabilities differed across workers with low and high levels of reward and over-commitment during computer use. The models contained two primary independent variables, over-commitment (low/high) and reward (high/low), and a term representing the interaction of reward and over-commitment. The interaction term was removed from the model predicting trapezius muscle activity variability because it was not significant.

Adjusted RMANOVA models tested the hypotheses that the effects reported for trapezius muscle activity median and variability were robust in the presence of confounders. Any of ten potential confounders (gender, age, height, weight, BMI, arm length, shoulder breadth, hand length, and hand breadth) that changed the partial eta squared by at least 10% when: over-commitment, reward, or the over-commitment-by-reward interaction were significant in the unadjusted models; or, over-commitment, reward, or the over-commitment-by-reward interaction became significant with the addition of the potential confounder, were added to the adjusted models. When two or more variables were highly correlated (Spearman coefficient greater than 0.6), only the variable with the largest effect on the partial eta squared was chosen. A Tukey's post hoc analysis was performed to determine which interaction values differed from others. Significance was defined as $p \leq 0.05$.

RESULTS

After adjusting for BMI, gender, hand length, and years having job requiring computing, there was a significant ($p=0.04$) over-commitment-by-reward interaction for median trapezius muscle activity (Figure 1). The median trapezius muscle activity value for participants with high over-commitment and low reward was approximately 6% MVC, and the median trapezius muscle activity value for participants with low over-commitment and low reward was 3.5% MVC. There was virtually no difference for high reward: the median muscle activity value was approximately 4.5% MVC for participants with low or high over-commitment (Figure 1).

There was a significant ($p=0.03$) main effect of over-commitment on trapezius muscle activity variability in the unadjusted model only. Participants reporting higher levels of over-commitment showed higher levels of variability in trapezius muscle activity (9.1% MVC vs. 7.6% MVC). There was no significant effect of reward ($p=0.52$) and no over-commitment-by-reward interaction ($p=0.36$), before or after adjusting for confounders.

DISCUSSION

The goal of this study was to investigate differences in trapezius muscle activities in office workers reporting different psychosocial stress levels, performing their own computer work at their own workstations. We observed the highest median trapezius muscle activity levels in participants with simultaneously higher over-commitment and lower reward. Participants with higher over-commitment also experienced higher trapezius muscle activity variability.

The results reported for median trapezius muscle activity support a pathway for psychosocial stress to increase musculoskeletal symptoms of the neck and shoulders via an increase in trapezius muscle activity. It appears that this effect, which has already been shown in the laboratory (Rietveld et al. 2007; Wang et al. 2011), is robust to the additional sources of variability that may be introduced in the field and occurs at levels and types of stress present in real life.

The observation that there was an interactive effect of over-commitment and reward on median trapezius muscle activity levels corresponds to the theory of Siegrist's effort-reward imbalance (ERI) model (Siegrist et al 2004). This model proposes that it is not necessarily the factors individually, but the combination of over-commitment and reward, that leads to increased psychosocial stress.

Contrary to our hypothesis, this study demonstrated that the variability in trapezius muscle activity increased for participants with higher levels of over-commitment. Increased variability may be protective against the effects of increased muscle activity levels on musculoskeletal symptoms (Visser & van Dieen 2006; Mathiassen 2006). However, the current study considered the effect of

psychosocial stress on trapezius muscle activity only across all computer use. Therefore, our results are dependent on the computer use patterns of participants of each psychosocial stress profile, and could be highly influenced if participants in a certain psychosocial stress profile performed different patterns of keyboard, mouse, and idle activities than those in another group, since a previous study has shown that trapezius muscle activity variability is influenced by task (Bruno Garza et al 2012).

This study considered only the effect of a particular theory of psychosocial stress, based on levels of over-commitment and reward, on trapezius muscle activity. Over-commitment and reward were selected because these factors have been shown to be associated with musculoskeletal disorders among computer users (Huysmans et al.2011). It is possible that other models of psychosocial stress, including the Karasek demand-control model, may also be associated with trapezius muscle activity or other biomechanical exposures during computer use.

If people experiencing high levels of over-commitment incur additional risk for neck and shoulder musculoskeletal symptoms via trapezius muscle activity, then this result may have implications for interventions. Changing the work environment in order to increase reward experienced by participants may be beneficial for workers' physical as well as their mental health status. The concept of reward encompasses factors such as "being treated fairly at work", "having a job in accordance with your education", and "getting support in difficult situations at work". The concept of over-commitment is a characteristic of individuals, including factors such as "being easily annoyed by time pressures at work" and "hardly being able to let go of work". This may indicate that effective interventions should include strategies for reducing psychosocial stress on an individual as well as a workplace level.

The distributions of over-commitment and reward were different across different departments. For this reason, although the study strategy aimed to recruit participants within the highest and lowest tertiles, the final study population had less contrast across levels of over-commitment and reward. Therefore, the true associations between

psychosocial stress and trapezius muscle activity may be greater than those reported here.

In conclusion, in this study we learned that participants reporting high over-commitment and low reward, indicating high psychosocial stress, experienced the greatest median muscle activity levels. This may help to explain the relationship between psychosocial stress and musculoskeletal symptoms of the neck and shoulders. This result would have implications for interventions as well as for the improvement of predictions of muscle activity for use in epidemiological studies.

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REFERENCES

- Blangsted, A.K., Hansen, K., & Jensen, C. (2004). Validation of a commercial software package for quantification of computer use. *International Journal of Industrial Ergonomics* 34(3) 237-241.
- Bongers, P.M., de Winter, C.R., Kompier, M.A., & Hildebrandt, V.H. (1993). Psychosocial factors at work and musculoskeletal disease. *Scandinavian Journal of Work and Environmental Health* 19(5) 297-312.
- Bongers, P.M., Ijmker, S., van den Heuvel, S., & Blatter, B.M. (2006). Epidemiology of work related neck and upper limb problems: psychosocial and personal risk factors (part I) and effective interventions from a bio behavioral perspective (part II). *Journal of Occupational Rehabilitation* 16(3) 279-302.
- NSR/IOM NRCaLoM (2001). Musculoskeletal Disorders and the workplaces: Low Back and Upper Extremities. National Academy Press, Washington, D.C.
- Bruno Garza, J.L., Eijkelhof, B.H., Johnson, P.W., Raina, S.M., Huysmans, M.A., van Dieen, J.H., van der Beek, A.J., Blatter, B.M., Dennerlein, J.T. (2012). Observed differences in upper extremity forces, muscle efforts, postures, velocities and acceleration across computer activities in a field study of office workers. *Ergonomics* Published Online First: 29 March 2012. doi:10.1080/00140139.2012.657692.
- Chang, C.H., Johnson, P.W., & Dennerlein, J.T. (2008). A wide range of activity duration cutoffs provided unbiased estimates of exposure to computer use. *Journal of Occupational and Environmental Hygiene* 5(12) 790-796.
- Feuerstein, M. 1996. Workstyle: Definition, empirical support, and implications for prevention, evaluation, and rehabilitation of occupational upper-extremity disorders. *Beyond Biomechanics: Psychosocial Aspects of Musculoskeletal Disorders in Office Work* 177-206.
- Huysmans, M.A., Ijmker, S., Blatter, B.M., Knol, D.L., van Mechelen, W., Bongers, P.M., & van der Beek, A.J. (2011). The relative contribution of work exposure, leisure time exposure, and individual characteristics in the onset of arm-wrist-hand and neck-shoulder symptoms among office workers. *International Archives of Occupational and Environmental Health* 29 PMID:22038090.
- Jensen, C., Vasseljen, O., & Westgaard, R.H. (1993). The influence of electrode position on bipolar surface electromyogram recordings of the upper trapezius muscle. *European Journal of Applied Physiology* 67(3) 266-73.

- Jensen, C. (2003). Development of neck and hand-wrist symptoms in relation to duration of computer use at work. *Scandinavian Journal of Work and Environmental Health* 29(3)197-205.
- Juul-Kristensen, B., Sogaard, K., Stroyer, J., & Jensen, C. (2004). Computer users' risk factors for developing shoulder, elbow and back symptoms. *Scandinavian Journal of Work and Environmental Health* 30(5) 390-398.
- Mathiassen, S.E. (2006). Diversity and variation in biomechanical exposure: What is it, and why would we like to know? *Applied Ergonomics* 37 419-427.
- National Research Council and Institute of Medicine. Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities. National Academy of Sciences 2001.
- Rietveld, S., van Beest, I., & Kamphuis, J.H. (2007). Stress-induced muscle effort as a cause of repetitive strain injury. *Ergonomics* 50(12):2049-58.
- Siegrist, J., Starke, D., Chandola, T., Godin, I., Marmot, M., Niedhammer, I., & Peter, R. (2004). The measurement of effort-reward imbalance at work: European comparisons. *Social Sciences & Medicine* 58, 1483-1499.
- Visser, B., & van Dieen, J.H. (2006). Pathophysiology of upper extremity muscle disorders. *Journal of Electromyography and Kinesiology* 16(3) 1-16.
- Wang, Y., Szeto, G.P., & Chan, C.C. (2011) Effects of physical and mental task demands on cervical and upper limb muscle activity and physiological responses during computer tasks and recovery periods. *European Journal of Applied Physiology* 111(11) 2791-2803.

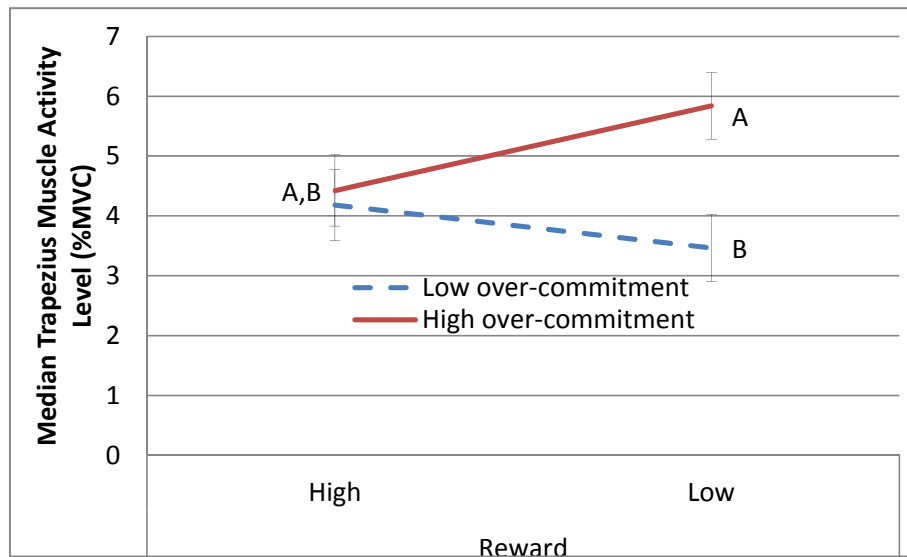


Figure 1. Least-squares means of the trapezius muscle effort median values from the repeated measures ANOVA model adjusted for BMI, Gender, Hand Length, and Years Having Job Requiring Computing (n=117). The error bars represent one standard error. Values with the same letters indicate no significant difference and groupings are ranked such that A>B. These data demonstrate the significant over-commitment and reward interaction.