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Abstract

Neck and shoulder disorders are a considerable health problem amongst frequent microscope users. We aimed to investigate the neck and shoulder discomfort experienced during prolonged microscopic activity and to assess the benefits of minibreaks. A prospective crossover study was performed on 17 healthy volunteers sitting still while looking down a bench with and without the Ipswich Microbreak Technique (IMT). We used a subjective measure of time to fatigue and pain in the neck and shoulder regions as well as objective readings from a surface electromyogram (sEMG). The IMT delayed the sensation of pain in the neck and shoulder region while reducing the overall sEMG muscle activation. In conclusion, IMT is a useful strategy in reducing and delaying the pain in neck and shoulder from prolonged working under the microscope. This technique can be incorporated in other activities that involve a sustained stationary position.

Keywords : mini-breaks, micropauses, neck pain, microscope, work-related musculoskeletal disorders

Introduction

Neck and shoulder disorders are a considerable health problem in the working population, with work-related causes representing a challenge both to the individual and societal economy (Hanvold et al., 2013). In 2014/2015, an estimated 233,000 people in Great Britain suffered from upper limb disorders (including neck and shoulder pain) which were caused or made worse by their work (Health and Safety Executive 2016, n.d.) Although this figure had not changed much since 2001/2002, there was still a total of 4,112,000 lost working days (Health and Safety Executive 2016, n.d.). Many doctors, including surgeons, are prone to such work-related musculoskeletal disorders (WRMSD) due to the nature of their daily job which can be physically demanding and emotionally exhausting (Cavanagh et al., 2012; Sakzewski and Naser-ud-Din, 2014; Soueid et al., 2010; Vijendren et al., 2015, 2014).

Various surgeons use microscopes; include general surgeons, plastic surgeons, vascular surgeons, neurosurgeons and otorhinolaryngologists. Its usage requires the operator to be in a stationary-seated position for a considerable period of time to enable concentration on their work field and regular bending of the upper body (Babar-Craig et al., 2004; Sivak-Callcott et al., 2015; Statham et al., 2010; Yu et al., 2016, 2012). Resultantly, it utilises large and small groups of muscles within the neck, shoulder, back and upper limbs. Such prolonged muscular inactivity can result in muscle ischemia and hypoxia, which has been shown to predispose individuals to acute and chronic musculoskeletal pain and disabilities (Strom et al., 2009). Souied et al. found that regular microscope usage was the second most common cause of intraoperative pain (after posture) amongst general surgeons, plastic surgeons, orthopaedic surgeons, otolaryngologists and neurosurgeons (Soueid et al., 2010). A separate study by

Babar-Craig et al. amongst Ear, Nose and Throat (ENT) surgeons in 2003 found that otologists had the highest prevalence of WRMSD due to their frequent microscopic work (Babar-Craig et al., 2004).

In recent times, there has been emerging evidence that microbreaks can help prevent a surgeon's fatigue and deterioration of performance associated with prolonged surgery (Dorion and Darveau, 2013; M. S. Hallbeck et al., 2017; Komorowski et al., 2015; Park et al., 2017). Many of these studies were conducted on surgeons performing open and laparoscopic procedures with resultant improvement in their physical and mental performance (Dorion and Darveau, 2013; M. S. Hallbeck et al., 2017; Komorowski et al., 2015; Park et al., 2017). Advancements were also seen in surgical precision and accuracy using smartphone applications and haptic feedback devices when surgical procedures conducted under microbreak conditions were compared to controls (Dorion and Darveau, 2013; Komorowski et al., 2015). Similar benefits were also noted within the IT (Mclean et al., 2001) and meatpacking industry (Genaidy et al., 1995) as well as during repeated data entry tasks (Henning et al., 1989).

Microbreaks described within the literature generally involves a 20-30 second stretching break during every 20-30 minutes of work (Dorion and Darveau, 2013; Hallbeck et al., 2017; Mclean et al., 2001; Park et al., 2017). However, there are no studies describing microbreak protocols during prolonged microscopic activity. With this concept in mind, we were keen to design a set of exercises for such a purpose. Our objectives were (a) to subjectively and objectively measure the onset of discomfort and pain of neck and shoulder muscles during microscopic work, (b) to review the literature and design our own set of microbreak exercises specific to microscopic work and (c) to compare the onset of neck and shoulder fatigue and pain with and without microbreaks.

Methods

1. Participants

17 participants, aged between 20 and 44 years (mean 28.9 ± 5.0 years), with no pre-existing musculoskeletal disorders or experience using microscopes on a regular basis completed all study protocols following familiarisation. There were 13 males and 4 females with a mean BMI of 25.4 ± 3.9. Baseline characteristics are provided in Table 1. Ethical approval was obtained from the University of Suffolk. As all participants were members of staff and affiliates of the University, National Health Service Research Ethics Committee (NHS REC) approval was not required.

2. Positioning

Participants were asked to sit on a standard desk chair without back support while focusing on cross-sectional arterial slides (chosen randomly) through a standard upright optical microscope (Olympus CX41RF). The height of the chair, position of microscope and table was adjusted individually to their comfort to ensure that they did not feel any strain prior to starting the recordings (Figure 1). The positioning was loosely based on existing ergonomic microscope standards (Helander et al., 1991; Kreczy et al., 1999; Sillanpaa and Nyberg, 2010), but did not strictly conform to them (eg. no back or arm rest) to avoid supporting the cervical and shoulder muscles. This was done to reduce any confounding variables that may arise from such external factors when investigating the overall effects of microbreaks on these muscles. Each participant was asked to sit in a posture that he/she felt most comfortable and was then instructed to maintain the same posture until the end of the experiment. This was to simulate the lack of movement during intense concentration when working using a microscope. Three assessors closely monitored the position of the participants during the recordings.

3. Measurement Techniques

We used both an objective measurement of muscular activity with surface electromyography and a subjective binary measurement of fatigue and pain.

3.1 Objective Measure (Surface Electromyography)

A 4-channel BIOPAC MP45 data acquisition system (BIOPAC Systems Inc., USA) collected sEMG signals for measurement of the muscular activity (signal amplitude, μV) (Moritani et al., 1986; Petrofsky, 1979; Petrofsky et al., 1982). The sEMG channels were amplified at a fixed gain of 1000 by the bio-amplifier, and were bandpass filtered between 5 and 1000 Hz. Bipolar surface electrodes were placed on the right-hand and left-hand sides of the neck as follows: the neck electrodes were placed at the midline from the acromion process to the spine of C7 vertebra with the electrodes 2 cm distant from each other. These electrodes measured the muscle activity of the upper branches of the trapezius descendens muscles (Seniam, 2006a).

An initial resting period of 60s was used for all participants, to ascertain a participant specific baseline sEMG value for each channel. Mean signal amplitudes of the left and right channels for the neck were averaged to provide a single output for normalization measurements (and subsequent experimental trials). All subsequent recordings were calculated as participant-specific percentages of their own initial resting value, thereby providing relative sEMG activation for each participant during the simulated procedures (% rest sEMG). Electrode placements were consistent among all participants using SENIAM (Surface Electromyography for the Non-Invasive Assessment of Muscles and industry guidelines (Seniam, 2006a)

3.2 Subjective measure (Time to Fatigue and Pain)

A two-point scale (time to fatigue and time to pain) of the neck and shoulder was used. We had defined fatigue as the point where onset of tension or sensations were felt at their neck / shoulder and pain as severe discomfort prompting them to move from their current static position. These definitions were clearly explained to participants prior to recordings. The sensations over both these areas were reported together as participants are not always able to differentiate one area from the other and tend to feel them over a larger surface (Vijendren et al., 2017). The measurements were stopped at the point when participants were unable to keep still because of neck or shoulder pain, or at 1200 seconds from the start of the procedure; whichever came first. The cut-off point of 1200 seconds was chosen based on results of our recent study where 10 male ENT clinicians experienced fatigue and pain in their neck musculature within 1200 seconds when looking under an operating microscope during similarly simulated conditions (Vijendren et al., 2017).

4. Procedure

4.1 Primary recordings

Male participants were requested to bare their upper torso and female participants were requested to wear a bareback top. The skin on their necks and shoulders were cleaned with alcohol gel and allowed to dry as per SENIAM guidelines (Seniam, 2006).The participants were then positioned at the microscope station and asked to focus on the displayed cross-sectional arterial slides. The sEMG activity of the neck / shoulder muscles were measured during these activities and the timescale for onset of fatigue and pain was recorded.

4.2 Literature review and Ipswich Microbreak Technique (IMT) development.

A literature search was performed via the engines PubMed, Embase, Medline, PsychINFO, BNI (Brtish Nursing index), CINAHL (Cumulative Index to Nursing and Allied Health Literature), HBE (Health Business Elite), HMID (Health and Medical Informatics Digest) and AMED (Allied and Complementary Medicine Database) using the following keywords in varying combination*; microbreaks, micro-breaks, micropauses, micro-pauses, minibreaks and mini-breaks.* This yielded 74 abstracts, which were independently reviewed by two authors. All conference abstracts, articles not relevant to musculoskeletal microbreaks and studies outside the English Language were excluded (58 abstracts). Sixteen full text papers were reviewed and a further two studies were excluded as these focused on mental alertness and stress-related microbreaks. The remaining 14 studies were summarised in Table 2.

Our search revealed that the nature of microbreaks varied across the studies performed, ranging from short rests to ad-hoc stretching exercises (Byström et al., 1991; Dorion and Darveau, 2013; Komorowski et al., 2015; Sundelin and Hagberg, 1989; Zhu and Shin, 2013). Our goal was to create a structured exercise regimen that would not only relax the postural muscles under tension but also aid in muscle recovery. The length of the microbreaks was set at 30 seconds based on optimum time derived from the literature, with prolonged breaks associated with high ratings of fatigue and boredom (Henning et al., 1989). The neck and shoulder region was targeted as the point of intervention as they have been shown to be the commonest areas under strain during prolonged microscopic activity (Babar-Craig et al., 2004; Vijendren et al., 2016, 2014). Our design was similar in parts to one described recently (M. S. Hallbeck et al., 2017) and were simple to comprehend, easy to perform and achievable within 30 seconds. Our recommendation was to perform the exercises after every 5-10 minutes of static microscopic activity. This is based on a recent study amongst 10 male ENT clinicians who experienced neck fatigue at 5.8±3.9 minutes and neck pain at 14.1±7.5 minutes during prolonged simulated microscopic work (Vijendren et al., 2017). Hence, we felt that the benefits of the IMT would be greatest before the onset of muscular discomfort. Such an interval is not dissimilar to other studies where microbreaks have been performed under 10 minutes (Byström et al., 1991; Sundelin and Hagberg, 1989; Zhu and Shin, 2013) – Table 2.

4.3 Secondary recordings

After completion of the primary recordings, all participants were shown a video and leaflet of the IMT (Figure 2) and were taken through the exercises in a step-wise fashion. The participants were subsequently given a 30-minute break to relax their upper limb muscles prior to commencing the next set of recordings.

Participants underwent the same measurement techniques and recordings as outlined in primary recordings. This time, an alarm was set to go off every 5 minutes (300 seconds) when participants would then carry out the IMT exercises as illustrated in Figure 2. They would then continue with the recordings after the exercises were completed. Hence, the recordings were divided into four periods; Period 1 = 0-300 seconds, Period 2 = 300-600 seconds, Period 3 = 600-900 seconds and Period 4 = 900-1200 seconds.

5. Data and statistical Analysis

All data were assessed for conformity with parametric assumptions, using the D'Agostino and Pearson normality test as recommended by Graphpad Prism 7 given the data sets included for analysis. Wilcoxon matched pairs signed-rank tests were used to test for differences between time to fatigue and pain separately, for conditions with and without IMT. Friedman test analysis was used to test for differences in % rest sEMG during the primary recording (without IMT), and the four IMT periods during secondary recordings (0 to 300s, 300 to 600s, 600 to 900s, and 900 to 1200s). For the primary recordings, mean sEMG data was gathered at rest period and the 30 seconds before participants experienced fatigue and pain, whereas mean % rest sEMG data for the secondary recordings were analysed at rest conditions and the 30 seconds preceeding the end of the aforementioned 4 periods. An alpha level of <0.05 was set as the threshold for statistical significance in all cases, and Graphpad Prism 7 (Graphpad Software Inc.) was used for all statistical analyses.

Results

1. Time to onset of neck and upper shoulder fatigue and pain

Without the IMT the mean time to fatigue was 668±381s (11 minutes and 8 seconds). With IMT, time to fatigue was 762±441s (12 minutes and 42 seconds; no difference between conditions, p = 0.66). Without IMT, mean time to pain was 1075±174s (17 minutes and 55 seconds). During the second set of recordings with the IMT, all participants did not experience pain when the experiment was concluded at 1200s, resulting in the time to pain to be significantly prolonged at >1200±0s (>20 minutes, p=0.008). Data are presented in Figure 3.

2. Surface EMG recordings

During the primary recordings, the participants had significantly different % rest sEMG readings during rest (101±2), fatigue (127±34) and pain periods (173±89), p=0.0001, Friedman statistic = 18.16. The inclusion of IMT resulted in no differences in mean % rest sEMG values during any of the four microscope periods (p=0.74, Friedman statistic = 1.98). Overall mean %rest sEMG was lower with IMT (110% vs 132%). All %rest sEMG data are presented in Figures 4a and 4b and 5.

Discussion

Our study found that the mean time to neck and upper shoulder fatigue was 11 minutes and 8 seconds and mean time to neck and upper shoulder pain was 17 minutes and 55 seconds amongst inexperienced microscope users. We also discovered that microbreaks can prolong the time required to experience pain and helped reduce the intensity of muscle contractions within these regions.

The role of microbreaks is well established within the IT and computer science industry (Mclean et al., 2001). The authors showed that microbreaks every 20 minutes amongst computer terminal workers had a positive effect in reducing discomfort within their cervical extensors, lumbar erector spinae, upper trapezius / supraspinatus and the wrist and finger extensions without detrimental effects on their productivity (Mclean et al., 2001). Similar results have also been noted within the meatpacking industry with workers reporting better subjective ratings of perceived discomfort with microbreaks (Genaidy et al., 1995). Bystrom et al's 1991 study set out to explore the physiological effects of micropauses to help clarify the mechanisms behind its advantageous effects (Byström et al., 1991).The authors looked at various parameters including heart rate, blood pressure, venous potassium and lactate concentrations as well as EMG readings of the exercising group of muscles and found no difference between control and microbreak conditions (Byström et al., 1991). Subjects did, however, report less fatigue with microbreaks and were noted to have a quicker return to maximal voluntary contractions, suggesting that muscular activity was under less strain and had a faster recovery period (Byström et al., 1991; Henning et al., 1989).

Similar to other findings, we found that IMT helped prolong the time our participants took to experience neck/shoulder pain in comparison to their controlled conditions. This correlated well with the sEMG findings where mean amplitude, a frequently used marker of neuromuscular fatigue with higher amplitude signaling more muscle fibre recruitment and increased muscle tension (Moritani et al., 1986; Petrofsky, 1979; Petrofsky et al., 1982), was unchanged across all microbreaks periods and collectively lower during IMT conditions (Figure 5). The time taken for the participants to experience neck/shoulder fatigue was also longer with IMT, albeit not significant which we feel may be a combination of inter-individual variation in their experience and reporting of the 'fatigue' sensation as well as our recording duration of 1200s. Irrespective of the 'p' value, the overall changes seen in sEMG and shift in mean time at the point of reported fatigue suggests that benefits do occur before pain is reported.

In addition to microbreaks, a myriad of other techniques have been described to help reduce the postural strain during prolonged static positions, which may benefit frequent microscope users. The ergonomics of the work environment is of paramount importance and workers should be able to control their working postures by adjusting the chair and desk height as well as the distance between themselves and the workstation (Rodigari et al., 2012). Moreover, a Cochrane review in 2012 found that the availability of an arm support can help reduce the cervical and thoracic postural load (Hoe et al., 2012) while our recent study looking at the benefits of a neck and back support chair during stationary microscopic activities has shown some promising results (Vijendren et al., 2017). With prior studies indicating a lack of awareness on ergonomic principles

(Cavanagh et al., 2012), we strongly feel that education within this field is a key ingredient for occupational productivity and longevity and ought to be incorporated in inductions and training systems. Such a feat is well supported by Cavanagh et al.'s ergonomic survey amongst paediatric ENT surgeons, noting that clinicians who were well informed on ergonomic principles were far more likely to incorporate them within their daily work (Cavanagh et al., 2012).

Limitations

Although our maximum recording duration of 1200 seconds based on our recent study (Vijendren et al., 2017) may have limited our results for neck pain, we felt that the overall outcomes had provided us with sufficient insight into the role of microbreaks within microscope users while efficiently utilising participants voluntary time without unduly strain from prolonged measurements. Reviewing the literature, we are aware of studies that have used shorter recording periods to show positive effects of the microbreaks (Sundelin and Hagberg, 1989; Zhu and Shin, 2013). We acknowledge that the 5-minute window used during the secondary recordings may be impractical in real-life, however, based on this and previous studies (Byström et al., 1991; Vijendren et al., 2017), feel that most regular microscope users would not be able to stay stationary for very much longer without experiencing strain.

In addition, while we accept that there may be many other large and small groups of muscles strained (eg. back, upper limbs, lower limbs) as a consequence of static postures during microscopic activity, the focus of our study was on neck and upper shoulder discomfort and consequently our microbreaks were specifically targeted to aid these areas. We also appreciate that the muscular tension during simulated scenarios may be different to the actual working environment where other psychosocial factors such as stress and time pressure may be present. It is equally important to acknowledge that an order effect cannot be completely ruled out, however we ensured that participants were fully rested in between both cycles and were given a chance to practice the IMT prior to secondary recordings in a bid to minimize the effect. Finally, we accept that our positioning during recordings had not strictly adhered to ergonomic microscope standards in a bid to not wholly support all cervical and shoulder muscles. We felt this would allow us to examine the full effects of the IMT and had tried our best to ensure recording conditions were standardized across all 17 participants.

Conclusion

Frequent microscope users are prone to neck and upper shoulder discomfort. Microbreaks are an effective way to aid the discomfort and muscle recovery. We have shown that the IMT, a structured exercise regimen, is advantageous for work-related musculoskeletal discomfort experienced during microscopic activity and can be performed within 30 seconds. While its effects have been investigated during microscopic work, we feel that the IMT may benefit the neck and shoulder muscles of any worker who performs prolonged tasks in a seated position (eg. computer terminal users, receptionists, administrative staff).

Tables

Participant	Age	Sex	BMI	Occupation	Existing MSK issues	Microscope experience
#1	27	M	23.6	Student	None	None
#2	44	M	25.6	Sports psychologists	None	None
#3	29	M	28.9	Lecturer	None	None
#4	32	M	22.6	Lecturer	None	None
#5	27	F	19.2	Cost Manager	None	None
#6	26	M	22.0	Technologist	None	None
#7	27	M	33.2	Student	None	None
#8	30	M	28.4	Database administrator	None	None
#9	30	M	21	Teacher	None	None
#10	24	F	22.1	Teacher	None	None
#11	31	M	26.5	Administrator	None	None
#12	20	F	21.1	Student	None	None
#13	30	M	27.0	Clinician	None	None
#14	27	M	25.8	Technical lead	None	None
#15	31	M	26.2	Communicati on Manager	None	None
#16	25	F	26.4	Security	None	None
#17	32	M	32.7	Manual labour	none	none

Table 1. Baseline characteristics of participants

*BMI = Body Mass Index, MSK = Musculoskeletal

Author and Year	Participant (N)	MB task	MB duration (s)	MB interval (m)	Study duration (m)	Outcome parameters
(Sundelin and Hagberg, 1989)	Word processor operators (12)	Rest and active exercises	15-20	6	30	Static muscular load
(Henning et al., 1989)	Data entry operators (20)	Rest	27.4	20	40	Keystroke rate, error rate, correction rate, heart rate and mood states
(Byström et al., 1991)	handgrip exercises (20)	Rest	10	3	Until exhaustion	EMG, physiological parameters
(Genaidy et al., 1995)	Meatpacking workers (28)	Stretching exercises	up to 120	180	360	Ratings of perceived discomfort
(McLean et al., 2000)	Computer terminal workers (18)	Rest	30	20	80	Myoelectric signal data
(Mclean et	Computer	Rest	30	20-40	180	Myoelectric

al., 2001)	terminal workers (15)					signal activity and self reported discomfort scores
(Balci and Aghazadeh, 2003)	College students (10)	Rest	30	15	360	Self-reported discomfort, data entry task
(Zhu and Shin, 2013)	Experiment asubjects (22)	Rest in upright position	6	0.5 - 1	7	EMG and anthropometric measurements
(Dorion and Darveau, 2013)	Surgeons (16)	Stretching exercises	20	20	120	Weight bearing, strength, accuracy testing
(Komorowski et al., 2015)	Surgeons (2)	Stretching exercises	30	15	60	Accuracy testing
(Park et al., 2017)	Surgeons and operating room staff (66)	Guided exercises	90-120	20-40	120-140	Self-reported pain scores, physicial and mental performance
(M. S. Hallbeck et al., 2017)	Attending surgeons (56)	Guided exercises	90-120	20-40	150-240	Self-reported pain and discomfort

(M. Hallbeck et al., 2017)	Surgeons and operating team members (33)	Stretching exercises	90-120	20-40	120-140	Physical performance, mental focus, self-rated workflow distraction
(Chaikumarn et al., 2017)	Visual display unit operators (30)	Rest, stretching and active exercises	180	20	60	3-dimensional motion analysis
(Vijendren et al,. 2017 – current study)	University staff and affiliates (17)	IMT	30	5	20	EMG, self reported discomfort and pain

Table 2. Literature review on microbreaks

*EMG = electromyelogram, IMT = Ipswich Microbreak Technique, MB = microbreaks, m = minutes, N = number of participants, s = seconds,

Figures

Figure 1a and b. Position of participants and electromyogram electrodes during measurements.

Figure 2. Ipswich Microbreak Technique (IMT)

Figure 3. Time to fatigue and pain in neck with and without the Ipswich Microbreak Technique (IMT)

*difference between pain in neck with and without IMT was significant at $p<0.05$

Figure 4a Group mean (+/- SD) % rest sEMG values during rest, fatigue and pain periods throughout primary recordings (without IMT)

* % rest sEMG = surface electromyelogram as a percentage of rest, SD = standard deviation, IMT = Ipswich Microbreak Technique

**$p = 0.0001$

Figure 4b. Group mean (+/- SD) of % rest sEMG values across all five periods throughout secondary recordings (with IMT).

* %rest sEMG rest = surface electromyelogram as a percentage of rest, SD = standard deviation, IMT = Ipswich Microbreak Technique

Figure 5. Overall sEMG comparison with and without IMT. Mean sEMG without IMT was 132% and mean sEMG with IMT was 110%.

* %rest sEMG rest = surface electromyelogram as a percentage of rest, IMT = Ipswich Microbreak Technique

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