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Effects of prolonged microscopic work on neck and back strain amongst male ENT clinicians and the benefits of a prototype postural support chair

1.0 Abstract

Musculoskeletal pain is a common occupational hazard experienced by surgeons. Otologists are predisposed to neck and back pain due to regular prolonged microscopic work. We conducted a prospective pilot study to investigate the effects of sustained microscopic work on the neck and back, its correlation to surgical experience and to assess the benefits of a prototype postural support chair (PSC) amongst 10 male ear, nose and throat (ENT) clinicians. We used a subjective measure of time to fatigue and pain for the neck and back as well as objective readings from a surface electromyogram (sEMG). We found that an increase in surgical experience correlated with the time taken to experience fatigue and pain in the neck and back. This was corroborated by our sEMG findings. The PSC significantly delayed the sensations in the neck and also eliminated the difference seen amongst the varying seniority of clinicians.

2.0 Introduction

A surgeon's daily workload renders him/her susceptible to a variety of occupational hazards [1]. Amongst the most common hazard is musculoskeletal fatigue and pain [1], which is contributed by daily strain from assisting in patient transfers and prolonged uncomfortable positions during lengthy operations [2]. Souied et al.'s 2010 survey amongst 77 UK consultant surgeons found that the neck and back were the areas most frequently affected [2]. These findings were corroborated within the ear, nose and throat (ENT) community where a national survey amongst 325 ENT consultants revealed that 72% had either back or neck pain or even both [3]. Fifty-three percent (53%) of respondents attributed their symptoms directly to surgery with otologists having the highest prevalence [3].

Despite extensive research, the exact intraoperative aetiology of neck and back pain is still unclear [4]. It is postulated to stem from a multifactorial cause of sustained isometric muscle contraction during low muscle activity and concurrent psychosocial workplace factors, such as stress during surgery and the ergonomics of the operating theatre [4,5,6].

ENT surgeons who perform operations on the ears, larynx, small vessels and nerves frequently need to engage in prolonged microscopic procedures, combining static postures and prolonged sitting. Such microscopic work during microlaryngoscopy [7] and within other specialties (eg. Plastic surgery and neurosurgery) has been shown to predispose the surgeon to neck and back strain [1,3,8]. Additionally, many of these procedures, for example mastoid

surgery, stapedectomy, tympanoplasty and microvascular anastomosis, are lengthy with minimal room for error requiring meticulous concentration which can place further strain onto the supporting muscles.

The aim of the current study is to investigate the neck and back strain experienced during intensive microscopic work and to assess if supporting the postural muscles with our own design of an ergonomic chair can delay the onset of such pain. To the best of our knowledge, this is the first study of its type amongst regular microscope users.

3.0 Methods

3.1 Ethical Consideration

The study was approved by the Hospital Trust Research Committee (2014/056). A formal ethics approval was deemed to be not necessary by the National Health Service Research Ethics Committee (NHS REC) as the study were performed on volunteering staff of a National Health Service (NHS) organisation.

3.2 Setting and Participants

The study was performed at the outpatient clinic of the ENT department. Ten volunteering male ENT clinicians (41 ± 11 years) were recruited for the study. They comprised of one foundation year 2 doctor, one nurse practitioner, two middle grades, three registrars, and three consultants. The average surgical experience for the group was 13 ± 10 years. Our three female clinicians were approached but had declined participation due to the possibilities of having to expose the upper torso for continuous surface electromyogram (sEMG) measurement. All volunteers were screened to ensure they had not sustained any acute musculoskeletal injuries within the previous one month. The baseline characteristics of the subjects are given in Table 1.

3.3 Assessment of neck and back strain

We used an objective measurement of muscular activity with sEMG and also a subjective measurement of fatigue and pain

3.3.1 Time to Fatigue and Pain in Neck and Back: The authors considered that existing tools such as rating of perceived exertion (RPE) and visual analogue scale (VAS) too complex for the current study and were keener for a binary form of measure. Hence, a two-scale measure for strain was used - onset of 'fatigue' and onset of 'pain'. 'Fatigue' was defined as the point where a sensation of tension or heaviness was felt and 'pain' as the inability to continue in their current static posture due to severe discomfort. The measurements were terminated at the point when participants experienced neck or back pain or at 1600 seconds from the start of the procedure, whichever came first. The arbitrary choice of 1600 seconds was chosen for practical reasons and the lack of consensus on standardised timing within such a cohort of participants. Participants who did not experience any fatigue or pain within 1600s and were able to continue with measurements beyond this time had their time scores set at 1600s.

3.3.2 Surface Electromyography: A 4-channel BIOPAC MP45 data acquisition system (BIOPAC Systems Inc, USA) collected sEMG for the measurement of the muscular activity (signal amplitude, μV). 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 and left hand side of the neck and back as follows: The neck electrodes were placed at the midline from the acromion process to the spine of C7 vertebra with the electrodes being at a 2cm distance of each other. These measured the muscle activity of the upper branches of the trapezius descendens muscles [6,7]. The back electrodes were placed at 2cm distances from each other at two fingers

width laterally from the spinous processes of L1 to measure the longissimus branches of the erector spinae muscles [6].

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 neck and back were averaged to provide a single output for neck and back normalisation 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 (sEMG %rest). Electrode placements were consistent among all participants using SENIAM (Surface Electromyography for the Non-Invasive Assessment of Muscles, www.seniam.org) [9] and industry [6] guidelines.

3.4 Microscopic procedure

3.4.1 Initial measurement: Participants had their skin cleaned with alcohol gel and allowed to dry as per SENIAM guidelines [10]. They then sat on a standard ENT operating chair (Figure 1a) and were asked to adjust the height of the chair and bed as well as their positions prior to starting to ensure any initial strain is minimized. The participants were requested to keep motionless and still while focusing on reading material through an operating microscope. This was to simulate the intense period of concentration required during microscopic procedures. Time to fatigue and pain as well as the sEMG activity of both neck and back muscles were continuously recorded for the entire duration of the

experiments until participants experienced undue pain or at 1600 seconds, whichever came first.

3.4.2 Prototype support chair: The PSC contains a sternal support as well as a cushion on which the forehead could rest on (Figure 1b). This was a modification of the standard operating ENT chair (SC). The aim of the headrest was to allow the neck to rest in a more neutral position, hence reducing the load on the upper cervical joints while possibly reducing any ischaemic changes within the neck musculature. The sternal support was added to maintain the neutral position of the cervical and thoracic spine, which would further reduce neck hyperextension. Although these mechanisms may help reduce lower back strain by allowing some anterior tilt of the pelvis, the primary effects of our prototype postural support chair were for cervical support. The measurements on neck and back strain were repeated on the same volunteers on a different day (to allow the muscles to recover) using the PSC (Figure 2).

3.5 Data Analyses

All data were assessed for conformity with parametric assumptions, using Shapiro-Wilk significance at $p < 0.05$. Pearson product moment correlation was administered to assess for linear dependence between surgeon experience in years, and onset of neck muscle fatigue with and without ergonomic support, onset of neck muscular pain without ergonomic support, and onset of back muscular pain with ergonomic support. Spearman's correlation was used to assess for linear dependence between surgeon experience in years, and onset of neck muscular pain with ergonomic support, onset of back muscle fatigue with

and without ergonomic support, and onset of back muscular pain without ergonomic support.

Wilcoxon signed-rank test was used to compare the standard chair against the prototype ergonomic support chair, for the onset time for both fatigue and pain at the neck and back. Non-linear regression (extra sum-of-squares F test) was used to assess for differences between the best-fit curve sEMG %rest values under SC and PSC conditions. An α level of < 0.05 was set as the threshold for statistical significance in all cases, and Graphpad Prism version 6 was used for all statistical analyses.

4.0 Results

4.1 Onset of Fatigue and Pain

4.1.1 Neck – Group mean time to onset of neck fatigue was 348s (5.8 min) and group mean time to onset of neck pain was 846s (14.1 min) using the SC. This was significantly prolonged with the use of the PSC to 1019s (16.9 min) and 1274s (21.2 min). This represented an increase of $672s \pm 520s$, $p = 0.007$ in time to fatigue and $427 \pm 467s$, $p = 0.021$ in time to pain.

4.1.2 Back - Time to fatigue in the back was around 502s (8.4 min) and time to back pain was 821s (13.7 min) using the SC. Although there were smaller delays in time to fatigue (622s [10.4 min]) and pain (1039s [17.3 min]) with the PSC, these did not reach statistical significant (delay in fatigue = $+120 \pm 522s$, $p = 0.111$, delay in pain = $+218 \pm 564s$, $p = 0.212$)

Group mean data is presented in Table 2.

4.2 Influence of surgical experience on time to fatigue and pain

4.2.1 Standard operating chair - Surgeon experience (years) was correlated with the time (sec) to fatigue at the neck ($R^2 = 0.91$, $p = 0.001$) and back ($R^2 = 0.76$, $p = 0.013$). For pain sensations, surgeon experience was again correlated with the time to pain at the neck ($R^2 = 0.74$, $p = 0.015$) and back ($R^2 = 0.90$, $p = 0.001$). Correlations presented in Figure 3 and 4.

4.2.2 Postural support chair – When using the PSC, no correlations were present for surgeon experience with either fatigue at the neck ($R^2 = -0.007$, $p = 0.851$) or back ($R^2 = 0.11$, $p = 0.763$), or with time to pain at the neck ($R^2 = 0.03$, $p = 0.842$) or back ($R^2 = 0.05$, $p = 0.884$). These correlations are presented in Figure 3 and 4.

4.3 Temporal surface electromyography

Non-linear regression shows significant differences in curves between the SC and PSC conditions for all ENT clinicians, for both temporal neck ($F = 91.1$, $p = 0.001$; Figure 5a), and back ($F = 14.59$, $p = 0.001$; Figure 6a) sEMG %rest values.

Given surgical experience significantly influences time to fatigue and pain during simulated microscopic procedures (and so the shape of temporal curves following non-consultants' test cessation), non-linear regression is also presented for non-consultant surgeons only ($n=7$). These also show significant differences between curves for the SC and PSC conditions, for both temporal neck ($F = 69.23$, $p = 0.001$; Figure 5b), and back ($F = 172.1$, $p = 0.001$; Figure 6b) sEMG %rest values.

5.0 Discussion

In this study, we found that prolonged microscopic procedures can cause fatigue (neck average = 5.8 min, back average = 8.4 min) and consequently pain (neck average = 14.1 min, back average = 13.7 min). In addition, ENT surgeon experience has correlated with the time taken to experience fatigue and pain in the neck and back, whereby greater surgical experience delays the time taken to experience both sensations. Our results have also found that a modified ergonomic postural support system significantly delayed the subjective time to fatigue and pain in the neck muscles and also reduced neck and back muscular activity while eliminating the difference initially seen amongst varying surgical experience.

We were fascinated to find the changes in fatigue and pain experienced with increasing surgical experience. We postulate that this may represent an element of postural adaptation of the neck and back muscles amongst senior ENT surgeons who have spent many years operating in particular anatomical positions. It would appear that junior surgeons place greater dependence on neck musculature to maintain postural stability whilst performing microscopic work, compared to their more experienced consultant colleagues. This is supported by both neck fatigue and pain correlation (Figures 3 and 4), and the difference in temporal sEMG time profiles seen when all clinicians are analysed together (Figure 5a) versus the non-consultants only (Figure 5b). Prolonged endurance activities elicit a variety of metabolic and morphological changes, including mitochondrial biogenesis, angiogenesis, fast-to-slow fibre-

type transformation and substrate metabolism [11,12,13]. These alterations have been postulated to be regulated by the activation of various co-enzymes of signalling cascades, such as mitogen-activated protein kinase (MAPK), AMP-activated protein kinase (AMPK) and peroxisome proliferator-activated receptor gamma co-activator 1 alpha (PGC-1 α) [11,13]. Consequently, the increased capillary supply, shift towards fat as the main catabolic substrate instead of glucose, enhanced mitochondrial function and tighter control of acid-base status, improves muscles' performance capacity [13]. This greater muscular function and reduction in build up of anaerobic metabolites may help explain the delayed onset of pain amongst senior surgeons in our study group. Maximising metabolic stress from such sustained static muscular activity has been shown to increase the adaptive response to endurance training through the aforementioned physiological changes [11].

Reviewing the literature, we found reports of personal experiences that adjusting operating table and chair height as well as leaning onto stationary equipment (e.g. arm rests and Mayo table) for elbow support can help reduce the intraoperative pain experienced [3,7]. Additionally, there was good evidence from a systematic review produced in South Africa that a chair intervention can help reduce musculoskeletal symptoms from workers who sit for prolonged periods [14]. This formed the basis for our PSC. Most surgeons working with microscopes have been noted to lean forward with a poking chin position for sustained periods of their operative time. This requires static contractions of the upper cervical musculature to sustain and support the position and weight of the head. The SC (Figure 1a) was selected for modification as it already had a built-in

design for adjusting its height as well as extendable arm rests which allowed easy conversion.

Besides prolonging the time to neck and back fatigue and pain, our PSC also eliminated the difference in experiencing neck and back strain between the varying seniority of clinicians (Figure 3 and 4). This would suggest that the support system could help reduce the postulated postural adaptation over time that causes chronic musculoskeletal problem, specifically by reducing the duration, awkward positions and force exerted on the postural muscles. Resultantly, it may be a tool for junior ENT clinicians to use at the beginning of their career to aid their future health.

The combination of subjective and objective measurements we had used has been commonly described in the literature [15]. The role of sEMG in recording muscle activity is well documented in many studies as it gives a continuous variation of muscular excitability [4,5,6]. Surface electrodes tend to be preferred in comparison to needle ones which can cause infection, damage to muscle fibres and pain to the participants [5]. In addition, there is good evidence to show that changes in sEMG activity is a reliable index of neuromuscular fatigue, characterized by increasing sEMG signal amplitude and decreasing frequency of contractions [5,16,17,18]. It is postulated that during sustained isometric muscle contractions, muscle fibers struggle to continue maintaining a high level of excitability resulting in lower frequencies of contraction with larger amplitudes in an attempt to compensate [5,6,13]. This would correlate well with our findings of rising sEMG amplitude and increasing fatigue experienced by the

participants throughout the length of their recording. Further corroboration can be found in studies by Hanvold et al. (2013) and Ostensvik et al. (2009) who have shown that sustained trapezius muscle activity can result in neck and shoulder pain [4,19].

We strongly feel that our results would not only be applicable to otolaryngologists' but also to other professionals who use microscopes on a regular basis (e.g. subspecialties of surgery, microbiologists, histopathologists and various other laboratory based scientists and technicians). Accordingly, the PSC may be implementable across these varying professions in a bid to improve their workplace ergonomics. In addition to our design, there is also a growing body of evidence inferring that incorporating exercises, assessment of ergonomics, adjustable equipment, ensuring breaks, change of position, and reducing the ergonomic risks could improve future health [20]. These techniques ought to be incorporated into the medical curriculum from an early stage.

6.0 Limitations

Our study was limited by a number of factors. Our participants were restricted to male ENT surgeons from a single ENT department and only ten were recruited. Nevertheless, we feel that this 'laboratory based' pilot study has provided us with a solid stepping stone to a larger project that would involve intraoperative measurements across all genders. It is also worth noting that although some of the non-consultants had spent more time in ENT than the consultants, the training in medicine is competency based resulting in consultants being better equipped in the art of operating with a microscopes compared to the non-consultants. This formed the basis of our grade based comparisons rather than time. We are also aware that our measures of 'fatigue' and 'pain' were highly subjective and open to inter-individual variability. However, we felt that our measure was simple for the participants to comprehend and straightforward for us to analyse. In addition, we acknowledge that the muscle activity and function of a surgeon during simulated surgical procedures may be very different to one during active operating where other groups of muscles may be involved while under various other stressors. This could suggest that the time to fatigue and pain may be slightly different in actual intraoperative procedures. Finally, we appreciate that the design of the PSC may not be practical for everyday use, however this was merely a prototype to show that supporting the postural muscles can have a positive effect in delaying neck and back muscular symptoms. We are currently in the process of improving it to a more pragmatic model.

7.0 Conclusion

ENT surgeons who perform prolonged microscopic work are at risk of musculoskeletal pain. We have shown that ENT surgical experience correlates with the time taken to experience fatigue and pain in the neck and back, whereby greater surgical experience delays the time taken to experience both sensations. We also found that an ergonomic support system can help delay the sensations of postural fatigue and pain while eliminating the difference seen amongst the varying seniority of clinicians. These risks may also exist within other professions who perform regular microscopic work such as pathologists, laboratory staff and watchmakers, who in turn could benefit from our ergonomic chair concept.

8.0 References

1. Vijendren A, Yung M, Sanchez J. The ill-surgeon: a review of common work-related problems amongst UK surgeons. *Langenbecks Arch Surg*. 2014 Dec;399(8):967-79
2. Soueid A, Oudit D, Thiagarajah S et al. The pain of surgery : Pain experienced by surgeons while operating. *International Journal of Surgery* 2010;(8):118-120
3. Babar-Craig H, Banfield G, Knight J. Prevalence of back and neck pain amongst ENT consultants:national survey. *The Journal of Laryngology and Otology* 2004;117(12):979-982
4. Hanvold TN, Waersted M, Mengshoel AM et al. The effect of work-related sustained trapezius muscle activity on the development of neck and shoulder pain among young adults. *Scand J Work Environ Health* 2013;39(4):390-400
5. Slack PS, Coulson CJ, Webster K et al. The effect of operating time of surgeons' muscular fatigue. *Ann R Coll Surg Engl* 2008; 90:651-657
6. Westgaard RH, Vasseljen O, Holte KA. Trapezius muscle activity as a risk indicator for shoulder and neck pain in female service workers with low biomechanical exposure. *Ergonomics* 2001;44(3):339-353
7. Statham MM, Sutkis AL, Redfern MS et al. Ergonomic analysis of microlaryngoscopy. *Laryngoscope* 2010;120(2):297-305
8. Capone AC, Parikh PM, Gatti ME et al. Occupational injury in plastic surgeons. *Plast Reconstr Surg* 2010;125(5):1555-61
9. Seniam.org [Internet]. European Union: Enschede; [cited 2014 25 December]. Available from <http://seniam.org/> - Sensor location option

10. Seniam.org [Internet]. European Union: Enschede; [cited 2014 25 December]. Available from <http://seniam.org/> - Preparation of the skin option
11. Baar K. Nutrition and the adaptation to endurance training. *Sports Med.* 2014;44Suppl 1:S5-12
12. Coffey VG, Hawley JA. The molecular bases of training adaptation. *Sports Med.* 2007;37(9):737-63.
13. Hawley JA. Adaptations of skeletal muscle to prolonged, intense endurance training. *ClinExpPharmacol Physiol.* 2002;29(3):218-22.
14. van Niekerk SM, Louw QA, Hillier S. The effectiveness of a chair intervention in the workplace to reduce musculoskeletal symptoms. A systematic review. *BMC Musculoskelet Disord.* 2012 Aug 13;13:145. doi: 10.1186/1471-2474-13-145.
15. Ohashi JY¹, Blangsted AK, Nielsen PK et al. Assessment of work-related muscle strain by using surface EMG during test contractions interposed between work periods of simulated mushroom picking. *J Hum Ergol (Tokyo).* 2010 Dec;39(2):57-68.
16. Moritani, T, Muro M, Nagata A. Intramuscular and surface electromyogram changes during muscle fatigue. *Journal of Applied Physiology* 1986;60:1179-1185.
17. Petrofsky, JS. Frequency and amplitude analysis of the EMG during exercise on the bicycle ergometer. *European Journal of Applied Physiology* 1979;41:1-15.
18. Petrofsky JS, Glaser RM, Philips CA et al. Evaluation of the amplitude and frequency components of the surface EMG as an index of muscle fatigue. *Ergonomics* 1982;25:213-223.

19. Ostensvik T, Veiersted KB, Nilsen P. Association between number of long periods with sustained low-level trapezius muscle activity and neck pain. *Ergonomics* 2009;52(12):1556-67
20. Dorion D, Darveau S. Do Micropauses prevent surgeon's fatigue and loss of accuracy associated with prolonged surgery? An experimental prospective study. *Ann Surg.* 2013 Feb;257(2):256-9

Tables

Clinician	Grade	Age (years)	Time spent in ENT (years)	Pre-existing musculoskeletal problem
1	Foundation Year 2 doctor	26	0.33	None
2	Nurse practitioner	37	10	None
3	Registrar ST3	30	3	Mild lumbar scoliosis
4	Registrar ST7	34	9	None
5	Registrar ST8	37	9	None
6	Middle grade	40	15	None
7	Middle grade	51	18	None
8	Consultant	40	12	None
9	Consultant	54	25	Prolapsed intervertebral disc L5/S1
10	Consultant	60	33	C7 radiculopathy

Table 1. Characteristics of study participants

Note; ENT = Ear, nose and Throat, ST = Specialty Trainee

Type of chair	Neck		Back	
	Time to Fatigue (s)	Time to Pain (s)	Time to Fatigue (s)	Time to Pain (s)
Standard chair	348 ± 235	846 ± 452	502 ± 487	821 ± 529
Postural support chair	1019 ± 453*	1274 ± 439**	622 ± 541	1039 ± 485

Table 2. Group mean (± SD) time to fatigue and pain.

Note ; * p = 0.007, ** p = 0.021

Figures

Figure 1: (a) Standard ENT operating chair, and (b) postural support chair.

Note; ENT = Ear, nose and throat

Figure 2: Positioning of volunteers during measurements using the postural support chair.

Figure 3: Clinician's experience (years, x axes), correlation with time (seconds, y axes) for (A) fatigue in neck and (B) pain in neck under standard (blue single line) and postural support chair (red double line) conditions.

Note; The full colour version of this figure is available online

Figure 4: Clinician's experience (years, x axes), correlation with time (seconds, y axes) for (A) back fatigue and (B) back pain under standard (blue single line) and postural support chair (red double line) conditions.

Note; The full colour version of this figure is available online

Figure 5. Group mean (and SD) temporal neck surface electromyography as a percentage of resting value (sEMG %rest), during both standard operating chair (blue single line) and postural support chair (red double line) conditions for (a) all clinicians and (b) non-consultants only.

Note; The full colour version of this figure is available online, error bars denote SD

Figure 6. Group mean (and SD) temporal back surface electromyography as a percentage of resting value (sEMG %rest), during both standard operating chair (blue single line) and postural support chair (red double line) conditions for (a) all clinicians and (b) non-consultants only.

Note; The full colour version of this figure is available online, error bars denote SD