Original Article

Surface electromyography of the cervical region - contribution to muscle health

Eletromiografia de superfície da região cervical - contribuição para a saúde muscular

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Abstract

Objective: To verify cervical pain symptoms in a group of office workers and investigate electromyographic signals of the upper trapezius muscle of office workers at rest.

Methods: Exploratory study with an interventional approach conducted with workers from a port facility. Personal, symptomological, occupational and electrophysiological variables were examined, based on electromyographies of the cervical region. The chi-square test, student's t-test and Mann-Whitney test were applied.

Results: Among the 43 workers who participated in the study, the mean score for shoulder and back neck pain was statistically higher among women than men. The formation of positive waves occurred before and after work, affecting ten workers. The completion of the workday did not cause signification modifications in cervical electrophysiological activity.

Conclusion: The study identified ergonomic variables and reports of cervicalgia, as well as positive wave recruitment in a small group of workers, indicating that the use of new muscle assessment instruments by nurses can enhance their occupational health work. The sex of the participants proved to be an important variable in muscle pain assessment, especially among women. The pre-workday period was also relevant, demonstrating that actions engaged in before work can positively or negatively influence muscle conditions for the workday. As a result of the study, a group of workers that require muscle health promotion was defined.

Resumo

Objetivo: Verificar sintomatologias dolorosas cervicais em um grupo de trabalhadores administrativos e investigar os sinais eletromiográficos do músculo trapézio superior de trabalhadores administrativos em repouso.

Métodos: Estudo exploratório, de abordagem intervencionista, realizado com trabalhadores da área portuária. Analisaram-se variáveis pessoais, sintomatológicas, ocupacionais e eletrofisiológicas a partir da eletromiografia da região cervical. Foram aplicados os testes qui quadrado, teste *t* de *Student* e *Mann Whitney*.

Resultados: Participaram 43 trabalhadores, que apresentaram média de nota para dor nas regiões do ombro e posterior do pescoço estatisticamente maiores entre mulheres do que entre homens. A formação de ondas positivas ocorreu antes e após o trabalho, afetando dez trabalhadores. A concretização da jornada de trabalho não produziu modificações significativas de atividade eletrofisiológica cervical.

Conclusão: O estudo identificou variáveis ergonômicas e a autorreferência de cervicalgia, bem como o recrutamento de ondas positivas em um pequeno grupo de trabalhadores, apresentando que o uso de novos instrumentos de avaliação muscular pela enfermagem pode contribuir para a atuação profissional à saúde do trabalhador. O sexo mostrou-se variável importante na avaliação à dor muscular, especialmente ao sexo feminino, assim como o período pré-jornada, indicando que as ações produzidas anteriormente ao trabalho podem influenciar, positiva ou negativamente, nas condições musculares para o desenvolvimento da jornada de trabalho. Desta forma, delimitou-se um grupo de trabalhadores que demandam promoção a saúde muscular.

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Introduction

The human musculature is exposed to improper conditions during work that can produce fatigue and functional incapacity, leading to metabolic modifications, which alter muscle activation patterns and capacity to produce force, in addition to generating painful symptoms. When these symptoms arise, the frequency of triggers of muscle motor units decreases and, consequently, muscle activation patterns are changed, which in the long term can damage the musculoskeletal system. Therefore, muscle pain leads to electrical muscle activation changes similar to those that occur with muscle fatigue.[1]

Among the most-taxed muscles is the trapezius, where the typical dorsalgia is cervicalgia, whose rates have risen in recent years.[2] Aspects such as age, sex, obesity, muscle force, sports activity, and socioeconomic and psychological conditions are individual risk factors that can promote muscle symptomologies in this region.[2] A study with nurses working on day and night shifts, for example, showed that most workers experienced pain in the trapezius muscle, regardless of the work shift. At night, the workload was lower, but workers on the night shift complained as strongly about pain as those on the day shift, which indicates that there are various factors that affect symptomology in this muscle.[3] Possible treatments include the use of deep needle and passive stretching techniques, which proved to be more effective than passive stretching among office workers with myofacial pain in this muscle.[4]

Ergonomic hazards, inherent to various production realms, impose improper demands on the body, such as office work where chairs may not be tailored to workers. Consequently, sitting will require greater muscle force and control to maintain stability, and may result in fatigue, discomfort and poor neck, upper limb and cervical spine posture habits.[4] This condition is directly related to the position of the head and vertical dimension at rest; incorrect body positioning creates a musculoskeletal imbalance that can also cause pain.[5,6] In addition, the proximity of the head and neck with innervation of the cervical spine may also produce pain in other body regions, such as orofacial, leading to various functional alterations.[7]

In the case of cyclists, for example, modifying the support of the hands promotes forward head posture, with a gradual increase in the perpendicular distance of the weight of the head and neck. This causes increased muscle force and neuromuscular activity which, in turn, generates conditions harmful to the spine.[8]

Technologies can be used to assess the variables involved in this process. These become work instruments for occupational health nurses and strengthen muscle disorder assessments, so that these disorders will not interfere with the performance of workers and, consequently, their productivity in the workplace.

Electromyography, mediated by electromyograph technology, enables studying the electrical activity of motor neurons and the muscle fibers innervated by them.[9] This device detects electrical potential caused by depolarization of muscle fibers at rest and during voluntary contraction. The use of electromyography is also for the purpose of evaluating the biomechanical conditions of the musculature of human beings. It can record myopathic patterns and signs of muscle membrane irritability, such as fibrillations, positive waves and myotonic discharges.[9]

In occupational health, this technology can be used for a variety of purposes, such as assessing muscle activity patterns during the workday and identifying areas of overload, tension and fatigue through increased electromyographic signal amplitude as a function of time, during sustained contractions with a constant load.[10] Considering the use of the cervical region in various activities during the workday, it seeks to determine the influence of the formation of electrical waves in relation to cervical symptoms among workers. It was found that performing activities during the workday increases muscle wave activity, which can contribute to the development of muscle pain.

The objective of the present study was to verify cervical pain symptoms in a group of office workers and investigate the electromyographic signals of the upper trapezius muscle of office workers at rest.

Methods

This was an exploratory, before-after study with an interventional approach, in which a health technology was used for muscle assessment in the cervical region - specifically the trapezius muscle. It was conducted in a port labor management department, and all the port workers, including interns, were invited to participate (n=53). The selection criterion was a 40-hour work week, and workers who were off due to illness were excluded, resulting in a total sample of 43 workers.

The data collection consisted of three stages, in which instruments belonging to the technological inventory of the socio-environmental laboratory for occupational health were used for electrical bioimpedance measurements, such as for weight, fat rates, muscle mass, body water percentage and bone mass. A portable digital scale with a capacity for 180 kg was used: Slimpro-180 model, 1731 series, from the Balmak® brand. The workers were positioned in the center of the scale, in an upright position, without shoes or socks.

In the second stage, electromyographic tests were performed using a Neuro-MEP Neurosoft® electromyograph, with eight channels. The positioning of the electrodes followed the technique proposed by the Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles (SENIAM). To properly measure the signal, the workers were placed in a seated position, with their feet resting on the ground, and their arms and legs uncrossed and relaxed, head unsupported and hands resting on their thighs. This helped expand signal capture and minimize noise interference during the test. The workers were at rest and maintained this position for 10 seconds to record the signals. The following procedures were performed: cleaning of the skin with gauze and 70% alcohol, placement of the electrodes, which were fastened with microporous tape, and verification of impedance, where less than 5 KΩ was accepted.

Electrical activity was captured by disposable Ag/AgCl surface electrodes (Neurobase® 301 - model 301H, 301I or 301J), and the Neuro-MEP.NET application (from Neurosoft®) was used to process the electromyographic signals. This application is responsible for digital acquisition and filtering (through amplifier units), storage and signal processing, and uses the Windows 7 operating system. The electrical activity of the muscle was captured at two times: at the beginning of the workday (the before measurement) and six hours later (the after measurement).

The third stage corresponded to identification of painful muscle points, as reported by the workers themselves. Every worker was given a schematic image of the human body to mark pain locations and assign a Visual Analogue Scale score, where zero signified absence of pain and 10, unbearable pain. The workers responded to a self-administered instrument validated by the research group with respect to sociodemographic and personal variables (marital status, other remunerated activities, domestic and physical activities, and smoking) and ergonomic and musculoskeletal variables (breaks at work, physical position assumed during the workday, work-related musculoskeletal ailments and occupational risks).

The statistical analysis of the data was performed using the Statistical Package for the Social Sciences (SPSS), Version 20.0. For the analysis of the anthropometric and bioimpedance measurements, simple frequencies, percentages and means were calculated, and inferential statistics were used for comparison of means through Student's t-test. For the electromyographic data analysis, in addition to descriptive statistics, inferential statistics, such as the chi-square test, were applied in the analysis of the variables maximum and mean amplitude and positive wave frequency, associated with the sex of the workers. Variables were also crossed, such as sex with pain reported, and wave recruitment count and maximum wave amplitude in relation to the workday, using the Mann-Whitney test. The bivariate Pearson correlation test was performed to verify cervical pain and the results of the electromyographic tests. All the tests were selected based on verification of data normality, using the Kolmogorov-Smirnov test. A significance level of 5% was used.

It is important to note that the study was not designed to perform a diagnostic electromyographic analysis in relation to desirable parameters for adequate muscle function, but rather to identify electromyographic changes in the trapezius muscle throughout the workday, in order to establish a possible relationship/link between work and cervical pain. This proposition was supported by other studies,[11,12] and the control parameter assumed was the case itself, i.e., the first measurement in relation to the second measurement (before and after measurements).

The study respected the ethical precepts of Resolution 466/2012, and workers were requested to sign two copies of a free and informed consent form. Ethical approval was also received for the macro research project entitled *Health of workers and occupational risks, accidents and diseases: a study in a port in the extreme south of Brazil,* associated with this manuscript, under No. 23116.004481/2013-53.

Results

Of the 43 workers who participated in the intervention in a port facility, 24 (45.3%) were men. The mean age was 34.8 years (standard deviation of 14.2), and 18 workers were single (41.9%).

The work characterization data showed that most of the workers identified ergonomic hazards at work, particularly time spent during the workday sitting down (27; 50.9%), work in inadequate postures (29; 54.7%), and repetitive movements (26; 49.1%). Thirty-three workers (62.3%) reported taking breaks. Most of the workers said they engaged in physical activities (29; 54.7%). In this variable, there was a statistically significant association with the sex of the study participants. Table 1 presents other data about the workers.

Among work-related musculoskeletal ailments, the main one was tendonitis, reported by five (11.6%) workers. In the anthropometric measurements, the mean height of the workers was 1.68 m (standard deviation of 0.11). The mean weight was 82.4 kg (standard deviation of 23.4 kg), with an overall body mass index of 26.8 kg, indicating overweight among workers. The other anthropometric measurements, according to sex, are presented in table 2.

The statistical analysis revealed significant differences between the sex of the participants and the means for height, weight and bone mass.

In relation to the occurrence of cervicalgia, most of the workers did not have any in the anterior regions of the neck (37; 69.8%) and shoulders (29; 54.7%), or in the posterior region of the shoulders (30; 71.4%) and neck (26; 63.4%). The mean score assigned to pain in the anterior and posterior regions of the shoulders and in the posterior region of the neck were statistically higher in women than men (U=134, <0.006; U=99, p<0.001; and U=139, p<0.012, respectively).

Table 1. Characterization of the workers

Characterization variables	Male n(%)	Female n(%)	p-value
Sociodemographic and personal			
Marital status			0.007*
Single	13(54.2)	5(26.3)	
Married	10(41.7)	5(26.3)	
Partner	0(0)	7(36.8)	
Separated	1(4.2)	2(10.5)	
Other remunerated activities			0.411
Yes	2(10.5)	1(4.2)	
No	17(89.5)	17(89.5)	
Domestic activities			0.613
Yes	21(87.5)	17(89.5)	
No	3(12.5)	2(10.5)	
Physical activities			0.015*
Yes	20(83.3)	9(47.4)	
No	4(16.7)	10(52.6)	
Smoker			0.788
Yes	2(10)	1(6.2)	
No	12(60)	11(68.8)	
Former smoker	5(25)	4(25)	
Ergonomics and musculoskeletal			
Breaks at work			0.473
Yes	19(79.2)	14(73.7)	
No	5(20.8)	5(26.3)	
Position assumed during the workday			0.276
Seated	13(54.2)	14(73.7)	
Standing	7(29.2)	2(10.5)	
Seated inclining the body	3(12.5)	1(5.3)	
Standing inclining the body	1(4.2)	0(0)	
Standing and squatting	0(0)	1(5.3)	
Work-related musculoskeletal disorder			0.267
Yes	4(23.5)	6(40)	
No	13(76.5)	9(60)	
Are there risks in your job?			0.493
Yes	4(16.7)	3(15.8)	
No	5(20.8)	7(36.8)	

*Statistical significance according to the chi-square test

Table 2. Mean and standard deviation of the anthropometric measurements, according to the workers' sex

Anthropometric measurements	Mean for women	SD	Mean for men	SD	p-value
Height (m)	1.58	0.01	1.75	0.01	0.000*
Body fat percentage	34.9	2.12	52.5	17.9	0.327
Body water percentage	45.2	1.94	45.2	2.45	0.924
Muscle mass percentage	23.6	1.65	26.0	1.70	0.430
Bone mass (kg)	2.33	0.06	3.27	0.11	0.000*
BMI	27.4	1.10	28.9	1.35	0.558
Weight (kg)	69.1	2.68	90.2	5.09	0.003

*Statistical significance determined through Student's t-test; SD - standard deviation; BMI - body mass index

In the electromyographic tests, positive wave counts produced by electrical impulses, in rest before work, occurred in five men and one woman. Variability in the electrical wave count was higher before work than after, among both men and women, but in most cases, regardless of the sex, there was no muscle fiber recruitment during rest. Among the five men, positive waves occurred before and after work, whereas with the female worker this change occurred only after engaging in work activities, as shown in Table 3.

There was a significant positive correlation between the score assigned to cervicalgia and wave count recruitment and maximum muscle wave amplitude ($p<0.027$ and $p<0.044$, respectively), indicating that the higher the score assigned to pain, the higher the number of recruited waves and the larger the amplitude of the muscle waves. In the chi-square test, there was no statistically significant association between positive wave count and sex of the workers before and after work.

The mean of the count of other types of electrical waves generated before the work shift of the men was higher than after (12.7 before work and 8.67 after). Among women, it was the contrary: the electrical wave count mean was higher after the work shift (9.89 before work and 11.05 after). The same occurred with the maximum amplitude of these waves produced during rest, at the time of the test. In men, the mean of the maximum amplitude was 121.72 μV before work, compared to 85.84 μV after work. For women, maximum amplitude before work was 93.83 μV, as opposed to 194.72 μV after work.

The six-hour workday did not cause significant changes in the wave recruitment count among the workers observed ($z=+1.130$; $p=0.258$); 21 workers had a higher number of waves before work and 19 after. There was a slight statistically significant alteration in the maximum amplitude of the electrical waves produced in the period studied ($z=-1.899$; $p=0.058$): for 23 workers it was higher before work and for 18, after work.

Discussion

A limitation of the study was that electromyographic tests were not applied to other muscle regions, due to logistical issues involved in adapting the electrodes to other regions of the body. This would have required an adequate physical location to provide privacy and proper conditions for positioning the workers. A bias associated with the type of work performed may also exist; the control of this variable was done through investigating workers from different professional categories, i.e., related to different types of production activities. There is also a possibility of bias associated with healthy workers, due to the exclusion of workers who were absent because of sickness.

The results showed that muscle assessments performed by nurses is an important task which, when combined with the use of electromyography, are able to identify important postural and electrophysiological elements for occupational health nursing care planning. Among office workers, for example, occupational variables did not affect the muscle function of men and women, where the gold standard was no muscle wave recruitment during rest. However, in the sample studied, the workers reported ergonomic hazards, particularly in relation to seated work, which constitutes an important occupational factor for the occurrence of muscle pain, such as in the lumbar region.[13]

Table 3. Count, maximum and mean amplitude, and frequency of positive waves, based on the sex of workers, according to the p-values of the chi-square test

Waves before work	Men (n)	Women (n)	p-value	Waves after work	Men (n)	Women (n)	p-value
Wave count			0.263	Wave count			0.313
0.00	20	17		0.00	22	18	
1.00	03	00					
2.00	01	00		1.00	02	00	
3.00	01	00					
4.00	00	01		3.00	01	00	
Maximum amplitude			0.513	Maximum amplitude			0.508
0.00	20	17		0.00	22	18	
94	01	00					
99	01	00		95	01	00	
122	00	01					
150	01	00		109	01	00	
166	01	00					
180	01	00		140	01	00	
Mean amplitude			0.513	Mean amplitude			0.508
0.00	20	17		0.00	22	18	
94	01	00					
99	01	00		79	01	00	
117	00	01					
138	01	00		95	01	00	
154	01	00					
166	01	00		140	01	00	
Mean frequency			0.418	Mean frequency			0.391
0.00	23	17		0.00	24	18	
0.30	01	00					
0.80	00	01		0.80	01	-	
69	01	00					

In terms of cervicalgia, its rates have risen in recent years. Among the workers examined, this symptomology was more significant among women. This may be directly related to the position of the upper structures of the body, as noted in a study with female workers, where those with cervical pain had greater oscillations in posture, affecting sensory systems and suggesting postural imbalance.[6] Furthermore, the proximity of the head and neck with innervation of the cervical spine may also produce pain in other body regions, such as orofacial, leading to various functional alterations.[7]

The position assumed by workers during the workday must be observed and included among measures to prevent muscle disorders, especially among the workers studied, considering that most of them worked sitting down. This was also identified among oral hygienists, whose work throughout the day is static, with flexion of the cervical region (neck) and inclination and rotation of the trunk which, combined with length of time in the profession, produces pain.[14] Another study also found that keeping the head balanced promotes postural alterations, such as head forward posture, which is more significant in individuals who complain of cervical pain than in asymptomatic individuals.[6]

In relation to the electromyographic tests, only six workers had positive waves, whose amplitude ranged from 20 to 500 mV - which is characteristic of conditions of muscle movement. However, these values do not indicate that the cervical muscles of these workers were affected by any kind of myopathy, such as radiculopathy, common in the identification of acute positive waves. This type of occurrence, in turn, may indicate a motor axonal injury, which is confirmed through electroneuromyography – a technique not applied in the present study. This condition also occurs because fibrillation potential and positive waves take around 3 to 4 weeks to be identified in distal muscles, such as those in the limbs. Therefore, early testing may indicate false negatives.[15]

Conditions that would lead to a false-positive diagnosis are tests of few muscles, with depth electrodes, which could hinder the detection of potential denervation in proximal muscles, acute lesions, more distal muscles, or lesions with a longer progression time.[15]

In relation to muscle activity, a study noted that fibrillation potential and acute positive wave amplitudes are related to the location of the muscle injury, sex and muscle size,[15] which contributes to justifying the difference in the presence of waves among male workers.

The occurrence of fibrillation potential may be related to muscle fiber size, also indicating that denervated muscle fibers that have suffered some level of atrophy may also manifest electromyographic positive wave signals. These results may be due to the composition of muscle fiber, which can be different in terms of aerobic capacity, strength performance and contractility, and lead to gender differences in spontaneous potential amplitudes in pathological conditions.[16]

In view of the anatomical and electrophysiological information on the health of the workers investigated, it can be seen that there is a need to keep workers and management attuned to national and international guidelines, which place importance on the environmental organization of work, such as types of seats and adjustable footrests and workstations, especially among those that require assuming a prolonged position throughout the workday. Training in the ergonomic area is also effective, as demonstrated in a study where the participants received ergonomics training and reported less musculoskeletal discomfort compared to participants with minimal training.[17]

Possible interventions noted in the studies include: the use of instruments such as compression socks; modification of surfaces; use of treadmills and insoles; and purchasing height-adjustable chairs, all of which significantly reduce symptoms and promote greater well-being in the workplace. Workers should be encouraged to frequently change their position switching between being seated, standing and bending.

This study indicated the need to expand the application of electromyographic testing to other professional categories, and to continue monitoring port workers, in view of the identification of individuals with wave recruitment during rest, reflecting muscle environment influence. In summary, a group of workers was detected for whom interventions will be prepared and implemented for muscle health promotion.

Conclusion

The study identified ergonomic variables and reports of cervicalgia, as well as positive wave recruitment in a small group of workers, which shows that the use of new muscle assessment instruments by nurses can enhance their occupational health work. The sex of workers proved to be an important variable in muscle pain assessment, especially among women, as well as prework activities, demonstrating that actions carried out before work can positively or negatively influence muscle conditions for performing work. As a result of the study, a group of workers in need of muscle health promotion was pinpointed.

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Collaborations

Mello MCVA, Silva LRW, Bonow CA and Cezar-Vaz MR worked on the project concept, data analysis and interpretation, writing of the article, relevant critical review of its intellectual content, and approval of the final version for publication.

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