Universidade de Lisboa
Faculdade de Motricidade Humana

Nociplastic pain in office workers with chronic neck pain

Alexandre Maurício Passos Nunes

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Tese especialmente elaborada para obtenção do grau de Doutor em Motricidade Humana na especialidade de Reabilitação

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Dedicação

À minha mulher, aos meus filhos,

que são os pilares da minha vida.

Aos meus pais e à minha tia,

que tenham muito orgulho em mim.

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Abstract

Chronic neck pain is highly prevalent in office workers. For a better treatment management plan is fundamental to classified the pain mechanism. The main aim of this thesis was to assess central sensitization in office workers with chronic neck pain comparing different pain conditions and different pain intensities. Thus, the thesis is presented in five articles format. The first study, a systematic review and meta-analysis found that all the pressure pain threshold measurements were lower in office workers with chronic neck pain compared with healthy workers. These assumptions were based on a small sample of existing studies. Importantly, this study proposed hypersensitivity reference values for localized and extra-segmental assessment of pressure pain thresholds in chronic neck pain. The second article, a structured web-based questionnaire, demonstrated a high prevalence of neck pain and a considerable number of body segments with pain in Portuguese office workers. The third study assessed pressure pain threshold, temporal summation of pain, and conditioned pain modulation, in different pain conditions and pain intensities. Office workers with moderate pain intensity demonstrated signs of sensitization demonstrated by widespread pressure hyperalgesia and enhanced temporal summation of pain. The fourth study added the assessment of maximal voluntary contraction in upper and lower trapezius, which was lower in those workers. The last study further demonstrated signs of sensitization in a higher number of office workers with chronic neck pain which had at least one quantitative sensory testing finding, being associated with pain intensity and pain rumination. It concludes that office workers with chronic neck pain self-reporting a moderate pain intensity, demonstrated signals of nociplastic pain. The assessment of the pain mechanism was possible with reference values and cut-off points in the quantitative sensory testing. Moreover, the presence of nociplastic pain was associated with pain intensity, pain rumination, and lower muscle strength.

Keywords: office workers, chronic pain, neck pain, nociplastic pain, quantitative sensory testing.

Resumo

Dor crónica na cervical é altamente prevalente em trabalhadores de escritório. Para uma melhor estratégia de tratamento é fundamental classificar-se o mecanismo de dor. O objetivo principal desta tese é avaliar a sensitização central em trabalhadores de escritório com dor crónica cervical, comparando diferentes condições de dor com diferentes intensidades de dor. Esta tese é constituída por cinco estudos. O primeiro estudo, uma revisão sistemática e meta-análise, verificou que o limiar de dor à pressão estava diminuído em trabalhadores de escritório com dor crónica cervical, comparando com trabalhadores saudáveis. Estas suposições foram baseadas em estudos com pequenas amostras. Importante foi propor valores hipersentitivos de referência para pontos locais e extra-segmentares, na avaliação do limiar de dor à pressão em dor crónica cervical. O segundo estudo, um questionário online, demonstrou uma prevalência elevada de dor cervical e um número elevado de áreas com dor em trabalhadores de escritório portugueses. O terceiro estudo, avaliou o limiar de dor à pressão, somação temporal e modulação condicionada de dor, em diferenças condições e intensidades. Trabalhadores com dor moderada demonstraram sinais de sensitização, devidos a uma hiperalgesia por pressão generalizada e uma somação temporal aumentada. O quarto estudo avaliou a contração voluntária máxima do trapézio superior e inferior, que nestes trabalhadores estava reduzida. No último estudo foi demonstrada a existência de sinais de sensitização num número elevado de trabalhadores com dor crónica cervical, que tiveram um teste quantitativo sensorial positivo, com associações entre intensidade e ruminação da dor. Concluiu-se que trabalhadores de escritório com dor cervical, que auto-reportam dor moderada, demonstram sinais de dor nociplástica. A avaliação do mecanismo de dor foi possível através de testes quantitativos sensoriais, usando-se valores de referência e pontos de corte. Além disso, a presença de dor nociplástica foi associada com intensidade da dor, ruminação e redução da força muscular.

Palavras Chave: trabalhadores de escritório, dor crónica, dor cervical, dor nociplástica, testes quantitativos sensoriais.

Abbreviation

BMI – Body mass index

CI – Confidence interval

CPM – Conditioned Pain Modulation

CPG - Clinical Practical Guidelines

CNP - Chronic neck pain

CON – Asymptomatic controls

COPSOQ – Copenhagen Psychosocial Questionnaire

CPT – Cold pressure test

ECU – Extensor carpi ulnaris muscle

HDD - Hand-held dynamometer

HR – Hazard Ratio

IASP - International Association for the Study of Pain

kPA – kilopascal

LT – Lower Trapezius

MD – Mean Difference

MVC – maximal voluntary muscle contraction

NDI – Neck Disability Index

NPRS – Numerical Pain Rating Scale

OD – Odds Ratio

PCS – Pain Catastrophizing Scale

PPT – Pressure pain threshold

QST – Quantitative sensory testing

RCT - randomized controlled trials

RR – Relative Risk

SE – Standard error

SD – Standard deviation

SMD - Standardized mean different

TSP – Temporal Summation of pain

TA – Tibialis anterior muscle

UT – Upper trapezius muscle

VAS – Visual Analogue Scale

YLDs - Years lived with disability

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Introduction

1 Introduction

Neck pain is a highly prevalent health problem in the general population (Walker-Bone et al., 2003; Côte et al., 2004; Bongers et al., 2006; Fejer et al., 2006; Hoy et al., 2010; Vos et al., 2016), and together with low back pain the leading cause of disability (Vos et al., 2016). In office workers, the prevalence of neck pain ranged from 20% to 60% worldwide (Sarquis et al., 2016), an incidence risk up to 35% (Gerr et al., 2002; Korhonen et al., 2003; Wahlström et al., 2004; Tornqvist et al., 2009; Paksaichol et al., 2014; Sihawong et al., 2016, Areerak et al., 2018), and a self-reported loss of productivity reported between 20% to 43% (van Heuvel et al., 2007).

Several retrospective and prospective studies researched the risk factors for the association of neck pain in office workers. The more consensual variables, with a higher predisposition for individual risk factors were "female gender" (Paksaichol et al., 2012), "previous history of neck complaints" (Jensen et al., 2003; Eltayeb et al., 2009; Paksaichol et al., 2012), and "no sports activities" (Cagnie et al., 2007). The work-related risk factors were: "working on the computer *per se"* (Juul-Kristensen and Jensen 2005; Eltayeb et al., 2009; Waersted et al., 2010; Andersen et al., 2011; Ranasinghe et al., 2011; Kiss et al., 2012; Piranveyseh et al., 2016; Jun et al., 2017), "work overload" (Cagnie et al., 2007; Hagberg et al., 2007; Ranasinghe et al., 2011), and "low task variation" (Jun et al., 2017). As for psychosocial factors, "high job strain" (Harcombe et al., 2009; Hagberg et al., 2007; Lindegärd et al., 2012), "individual somatization" (Harcombe et al., 2009; Oha et al., 2014), "work attribution beliefs" (Oha et al., 2014), the sensation of "high muscle tension" (Jun et al., 2017), "depressed mood" (Shahidi et al., 2015), "mental tiredness at the end of the workday" (Cagnie et al., 2007), and "no comfort at work" (Lindegärd et al., 2012; Jun et al., 2017) have been identified.

Very importantly, to reduce neck pain in office workers, it is essential to address the modifiable risk factors. Research on ergonomic and workplace interventions targeting work-related risk factors provided low-quality evidence of reducing of neck pain in office workers (Aas et al., 2011; Hoe et al., 2012; Chen et al., 2018; Hoe et al., 2018). Strength exercise can modify some of the risk factors and improve neck muscle strength in office workers with chronic neck pain (CNP) (Schulte et al., 2006; Sjøgaard et al., 2006; Andersen et al., 2008; Nielsen et al., 2010; Bech et al., 2017). From systematic reviews, there was conflicting evidence that strength exercise is effective in reducing neck pain (Sihawong et al., 2011; Chen et al., 2018; Frutiger & Borotkanics, 2020).

When analysing treatment research, some of the modifiable risk factors were not encompassed. The continuous exposure to the factors, the lack of reporting of pain characteristics and sources of neck pain can explain the results (Sihawong et al., 2011). Moreover, there is weak evidence in the diagnosis and classification of neck pain (Blanpied et al., 2017). Traditionally, studies addressing CNP in office workers classified it as non-specific neck pain. However, when the pain becomes chronic, it causes neuroplastic changes within the nervous system (peripheral or central). Therefore, based on this concept, it would be fundamental to classify the pain mechanism as nociceptive, neuropathic or nociplastic pain, for a better treatment management plan (Boudreau et al., 2010; Pavlakovic & Petzke 2010; Arendt-Nielsen et al., 2011; Pelletier et al., 2015; Chimenti et al., 2018; Freynhagen et al., 2019).

Nociplastic pain is defined as "pain that arises from altered nociception despite no clear evidence of actual or threatened tissue damage causing the activation of peripheral nociceptors or evidence for disease or lesion of the somatosensory system causing pain" (Kosek et al., 2016; Trouvin & Perrot, 2019). This new concept implies an inference of central sensitization, which can be assessed through quantitative sensory tests (QST) (Kosek et al., 2016), namely pressure pain threshold (PPT), temporal summation of pain (TSP), and conditioned pain modulation (CPM). PPT assessed in a painful and non-painful area, can differentiate in a quantifiable way localized muscle hyperalgesia (peripheral sensitization) from widespread hyperalgesia (central sensitization) (Arendt-Nielsen et al., 2011, 2018). TSP assesses the wind-up process reflecting dorsal horn excitability (Latremoliere & Woolf, 2009; Pelletier et al., 2015), and CPM tests the inhibitory pain mechanism (Heinricher et al., 2009; Pelletier et al., 2015). Psychosocial factors as depression, stress, pain catastrophizing, or the mentioned psychosocial risk factors contribute to pain inhibition or facilitation (Heinricher et al., 2009), with some association between those factors and QST, so that further studies are needed to quantify it in CNP (Malfliet et al., 2015; Georgopoulos et al., 2019).

Moreover, nociplastic pain does not exclude nociceptive pain. The continuous presence of inflammatory mediators in the periphery contributes to persistent pain states (Petrenko et al., 2003; D'Mello & Dickenson 2008; Latremoliere & Woolf 2009; Woolf 2011). In office workers, there is a strong association between neck pain intensity and trapezius muscle tenderness (Brandt et al., 2014). Work-related trapezius myalgia is a common disorder affecting the neck/shoulder area in office workers performing monotonous and repetitive tasks, mainly on a computer (Juul-Kristensen et al., 2006; Larsson et al., 2007). In cases of chronicity, there are some findings suggesting central sensitization (Sjors et al., 2011). Also, there is some evidence that office workers with more severe CNP demonstrate signals of central sensitization through QST (Johnston et al., 2008; Ge et al., 2014). There is still a lack of studies addressing central sensitization in CNP in specific populations, mainly the lack of TSP (Malfliet et al., 2015; Georgopoulos et al., 2019).

The present thesis, entitled "Nociplastic pain in office workers with chronic neck pain" aims to assess central sensitization in office workers with chronic neck pain, comparing the differences between pain conditions with pain intensities. First of all, it was necessary to assess the prevalence of neck pain and to identify occupational factors associated with neck pain in Portuguese office workers. Afterwards, this thesis investigates the associations between pain intensity and disability with pain catastrophizing, psychological factors, muscle strength, and pain sensitivity measures. Finally, an additional aim was to provide reference values to assess sensitization through quantitative sensory testing in office workers with chronic neck pain.

This thesis assembles a literature review, methodology, and a compilation of five articles. It is thus structured as follows:

1.1 Dissertation Structure

Chapter 2 includes a literature review of the topic of exploring and developing the pillars for conducting this thesis. Neck pain prevalence, risk factors, incidence and loss of productivity in office workers. Based on those concerning numbers, treatment effectiveness, neck pain classification and diagnosis, and finally, nociplastic pain are discussed.

A brief methodology is presented in **chapter 3**, with an overall indication of each article methodology. **Chapter 4** is a systematic review and meta-analysis to provide data for pressure pain threshold in office workers with chronic neck pain.

Chapter 5 is the online survey to assess the occupational risk factors for the association of neck pain in office workers.

In **Chapters 6 and 7** office workers were stratified accordingly with pain condition and intensity for the association analysis between pain intensity and disability with quantitative sensory testing, pain catastrophizing, psychosocial factors (chapter 6) and muscle strength (chapter 7).

Chapter 8 provides an interpretation for conducting simple clinic bedside quantitative sensory testing to assess sensitization in office workers.

Chapter 9 corresponds to a general discussion that provides a summary and integrated discussion of the main findings obtained from the five articles of this thesis.

1.2 List of publications related to the dissertation

Peer-reviewed articles published, submitted or under review.

Nunes, A., Moita, J., Espanha, M., Arendt-Nielsen, L., Petersen, K. (2020). Pressure pain thresholds in office workers with chronic neck pain. A systematic review and meta-analysis. Pain Practice, 2021.

Nunes, A., Espanha, M., Teles, J., Carnide, F., Petersen, K., Arendt-Nielsen, L., Carnide, F (2020). Neck pain prevalence and associated occupational factors in Portuguese office workers. International Journal of Industrial Ergonomics, accepeted to be published.

Nunes, A., Espanha, M., Arendt-Nielsen, L., Petersen, K. (2020). Sensitization in office workers with chronic neck pain in different pain conditions and intensities. Scandinavian Journal of Pain, 2020.

Nunes, A., Miguel, J., Espanha, M., Arendt-Nielsen, L., Petersen, K. (2020). Upper and lower trapezius muscle strength in female office workers with chronic neck pain. Journal of Manipulative and Physiological Therapeutics (minor review).

Nunes, A., Arendt-Nielsen, L., Espanha, M., Julia, T., Petersen, K. (2020). Bedside clinical tests to assess sensitization in office workers with chronic neck pain. Somatosensory & Motor Research (under review).

Abstracts

Nunes, A., Espanha, M., L. Arendt-Nielsen, K. Petersen (2019). Differences in pressure pain threshold in computer workers with chronic trapezius myalgia, non-specific chronic neck pain and healthy workers. 11th Congress of the European Pain Federation EFIC, Valencia, Spain, 4-7 September, pp 144.

Conferences

Nunes. A. (2017). Chronic trapezius myalgia in computer workers, relation between pain, body image and disability – methodology for randomized controlled trial. Conference QUANTUM, 3rd Annual Meeting of the Foundation C.O.M.E. Collaboration, Barcelona, Spain, 30th September-1st October

Nunes, A. (2019). Differences in experimental pain assessment in computer workers with chronic trapezius myalgia, non-specific chronic neck pain and healthy computer workers. 12th Osteopathic International Symposium of Nantes, France, 16-17th March.

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2

Literature Review

2 Literature Review

In the Global Burden of Disease in 2015, the prevalence of neck pain was 21.1%, and together with low back pain, they were globally the leading cause of years lived with disability (YLDs) and the leading cause of YLDs between 25 to 64 years of age. In Portugal, they were the first cause of YLDs with a ratio of 1.34 between the observed and expected YLDs based on the Socio-demographic Index (Vos et al., 2016). In the working population, neck pain is highly prevalent, with an annual prevalence between 15 to 75% depending on the specific occupation (Côté et al., 2008).

2.1 Prevalence of neck pain in office workers

In office workers, the generalized pain involving neck/shoulder ranged from 20% to 60% which is a problematic issue for this professional category and, unfortunately, a constant verified worldwide (Sarquis et al., 2016). The prevalence of neck pain in the last 12 months in Europe ranged from 10.3% to 68.6%, wherein in the Netherlands it was between 10.3% and 33% (Blatter & Bongers, 2002; Eltayeb et al., 2009), in Denmark it ranged from 10.6% to 44.7% (Jensen 2003; Brandt et al., 2004; Juul-Kristensen & Jensen, 2005; Madeleine et al., 2013), in Finland it was 68.6% (Sillanpää et al., 2003), in Sweden it was 48% (Wahlström et al., 2004), in Belgium it was between 45.5% and 50.2% (Cagnie et al., 2007; Kiss et al. 2012), in Portugal it was 19.2% (Cunha-Miranda et al., 2010), in Estonia it was 51% (Oha et al., 2014), and in Turkey it ranged from 42.6% to 61.9% (Celik et al., 2017). In Asian countries, it followed the same pattern: in Japan it was 27% (Matsudaira et al., 2011), in Sri-Lanka it was 36.7% (Ranasinghe et al., 2011), in India it was 43.4% (Darivemula et al., 2016), in Iran it was 49% (Piranveyseh et al., 2016), and higher in Taiwan with 71% of office workers with neck pain (Cho et al. 2012). The same in Oceania countries, the average in New Zealand being 29% (Harcombe et al., 2010), and 62% in Australia (Chen et al., 2018a). Therefore, the prevalence of neck pain in office workers is not cultural.

The prevalence was higher in female office workers when compared with male office workers (Gerr et al., 2002; Korhonen et al., 2003; Brandt et al., 2004; Andersen, J. H., et al. 2008; Janwantanakul et al., 2008; Hush et al., 2009; Cunha-Miranda et al., 2010; Ranasinghe et al., 2011; Kiss et al., 2012; Paksaichol et al., 2012; Madeleine et al., 2013; Oha et al., 2014; Celik et al., 2017). The prevalence tended to be higher in elderly office workers (Juul-Kristensen et al., 2006; Oha et al., 2014).

2.2 Incidence risk of neck pain in office workers

The prevalence rate is not the only concern. The incidence risk and loss of productivity due to neck pain and upper limb symptoms are other issues studied in this population. In a large sample size of 4548 Danish office workers, the incidence risk of moderate neck pain was 1.5% in a one-year follow-up (Brandt et al., 2004), and in a sample size of 2146 office workers, 2.02% developed chronic neck pain (CNP) in one-year follow-up (Andersen, J. H. et al., 2008). Those were the studies that reported lower incidence risks. However, there was at least one exception, the study from Tornqvist et al. (2009) with 1247 OW, where the incidence risk was 35%.

Therefore, it is essential to analyse the possible explanations. A larger sample size can be one of the reasons. In fact, in smaller sample sizes, less than 632 office workers, the incidence risk ranged from 27% to 34% (Gerr et al., 2002; Korhonen et al., 2003; Wahlström et al., 2004; Paksaichol et al., 2014; Sihawong et al., 2016; Areerak et al., 2018).

Another important fact was the criteria to account for a new case, where the studies with a smaller sample size considered for incidence risk, the onset of neck pain. Wherein the study from Brandt et al. (2004), only those office workers who reported symptoms to be at least with moderate symptoms were considered a new case, and in the study from Andersen, J. H. et al. (2008), the reported number was of those who developed CNP.

Besides, there are other alarming signs. The average of the development chronicity in the onset of neck pain in office workers was between 17% to 21% (Shahidi et al., 2015; Sihawong et al., 2016), and in prospective studies with a longer follow up period (2 years), the incidence risk was between 20% to 27% (IJmker et al., 2011; Huysmans et al., 2012), with an incidence risk every three months between 3.9% to 8.8% (IJmker et al., 2011) and a mean of 3.9% (Huysmans et al., 2012).

2.3 Productivity loss of office workers with neck pain

The average self-reported productivity loss varied between 20% and 43%. In the study from Hagberg et al. (2002), it was 25% in office workers with CNP, and in van de Heuvel et al. (2007) was 20%, increased to 36% when there were also arm/hand symptoms. Those results were similar to the study from Madeleine et al. (2013), were 21.5% and 16.9% of women and men office workers reported an inability to perform daily work due to neck and shoulder pain.

The loss of productivity from sickness absence due to neck pain was 32%, increased to 43% when together with upper limb symptoms (van de Heuvel et al., 2007). Finally, office workers with neck pain had a risk of 2.9 times (OR=2.9, CI=1.2-6.7) of sickness absence (Matsudaira et al., 2011).

2.4 Risk factors for neck pain in office workers

Due to the high incidence risk, productivity loss, and the prevalence of neck pain in office workers, constant during the years and decades, conveyed the research teams to investigate and ask some questions, namely: which are the risk factors for the onset of neck pain in office workers during continuous work? Which risk factors can be modified, and does treatment address those specific factors (O'Sullivan et al., 2016).

The risk factors can be divided into three main categories: individual, work-related, and psychosocial factors (Paksaichol et al., 2012).

2.4.1 Individual risk factors

In this category, the scientific research studied gender, age, and BMI with neck pain. There is a consensus in the literature regarding gender (Paksaichol et al., 2012), but there is conflicting evidence as far as age is concerned, with no association with neck pain (Jensen et al., 2003, Jull-Kristensen & Jensen, 2005; Ranasinghe et al., 2011; Paksaichol et al., 2012; Celik et al., 2018). The study from Gerr et al. (2002) reported a slight increase in the risk ratio of 0.3 points from the age of 30-39 to more than 40 years. However, Cagnie et al. (2007) found a U-shaped association where the pain increased until the age of 50 years, and then it started to decrease. Concerning BMI, only the study from Sihawong et al. (2015) found that this was a slight significant risk factor, with no associations with neck pain in the studies from Brandt et al. (2004), Cagnie et al. (2007), and Hagberg et al. (2007).

In a prospective longitudinal cohort study with 24 months follow-up, the self-reported "previous history of neck complaints" increased seven times the risk of neck pain (Eltayeb et al., 2009) with strong evidence for the association of neck pain in office workers (Paksaichol et al., 2012). In another prospective longitudinal cohort study with 12 months follow-up, the "initial pain intensity" increased more than twice the risk of ongoing neck pain (Sihawong et al., 2016) (Table 2.1).

Thus, it is essential to mention that some health factors had some protective factor for neck pain, such as a "good mental health" (OR: 0.89, CI: 0.84–0.94, $p<0.001$) (Harcombe et al., 2009), or the range of motion of the cervical spine in flexion-extension movement (HR:0.44, CI:0.19-1.05, *p*=0.028) (Hush et al., 2009).

Table 2.1 – Individual risk factors for neck pain in office workers

Variable	**Study**	**Strength Association (95% CI)**	***P* value**
BMI	Sihawong et al. 2015	OR: 1.1, CI:1.0–1.2	0.01
Previous history of complaints	Jensen et al. 2003	OR: 2.8, CI:1.9-4.1	<0.001
	Eltayeb et al. 2009	OR:7.2, CI:3.8-13.6	<0.001
	Gerr. et al 2002	RR: 3.3, CI: 2.1-5.2	<0.05
Initial pain intensity	Sihawong et al. 2015	OR:2.27, CI:1.74-2.96	<0.001
Current or ex-smoker	Korhonen et al. 2003	OR: 1.9, CI:0.8-4.3	NA
Not being physical active	Cagnie et al. 2007	OR:2.08, CI:1.49-3.16	<0.001
Working years on computer	Andersen, J. H. et al. 2008	OR:2.53, CI:0.84-7.56	NA

Abbreviations: NA – Not attributed; OR - Odds ratio; RR – Relative Risk.

2.4.2 Work-related risk factors

In the past two to three decades, considerable research studied the association of work-related risk factors with neck pain through retrospective and prospective designs, and therefore, it is essential to analyse and compare their results. For this purpose, the results from a systematic review and meta-analysis from Jun et al. (2017) with prospective studies will be compared from data of retrospective studies.

The variable "working without a break", the recommendation is to take a break at least every hour for a total of 5 to 15 minutes to vary tasks and reduce the workload at the display screen (NIWL 2001). Less "number of break times" in retrospective studies was associated with neck pain (Cagnie et al., 2007; Kiss et al., 2007; Celik et al, 2018), with no association in other studies (Hagberg et al., 2007; Ranasinghe et al., 2011). In the meta-analysis, the result was RR: 1.13, CI: 0.92-1.39 without a statistical significance (Jun et al., 2017).

In "working computer work *per se",* from 9585 office workers, more than 75% of the total hours of work was performed on the computer was associated with neck pain (Juul-Kristensen & Jensen, 2005; Eltayeb et al., 2009; Ranasinghe et al., 2011; Kiss et al., 2012; Piranveyseh et al., 2016) and from two prospective studies was RR: 1.07, CI: 0.91-1.24 without a statistical significance (Jun et al., 2017). Those results were in line with previous systematic reviews (Waersted et al., 2010; Andersen, J. H. et al., 2011). These results can be increased when the "work is overload" (Cagnie et al., 2007; Hagberg et al., 2007; Ranasinghe et al., 2011), and with a "low task variation" (RR: 1.27, CI: 1.08-1.50, p=0.005) (Jun et al., 2017).

From the prospective studies, there was a statistical significant association between neck pain with "close keyboard position" (RR: 1.46, CI: 1.07-1.99, p=0.02). In the retrospective study from Korhonen et al. (2003), there was an association with neck pain, but not in several others studies (Sillanpää et al., 2003; Brandt et al., 2004; Hagberg et al., 2007; Celik et al., 2018).

Regarding the "screen position relative to eye level" an association with neck pain was found in two studies (Jensen et al., 2003; Sihawong et al., 2016) but not in others studies (Brandt et al., 2004, Hagberg et al., 2007; Jun et al., 2017; Celik et al., 2018). Interestingly enough, a not adjustable screen position causes changes in head posture, such as holding the neck in a forward bent posture with association with neck pain (Cagnie et al., 2007; Eltayeb et al., 2009).

The research is more against an association of risk factors related to "mouse work" (Jensen et al., 2003; Sillanpää et al., 2003; Brandt et al., 2004; Hagberg et al., 2007; Jun et al., 2017; Celik et al., 2018), "keyboard work time" (Jun et al., 2017), "arm support" (Jensen et al., 2003; Brandt et al., 2004; Celik et al., 2018), than in favour (Kiss et al., 2012). Table 2.2 only refer to the OR with a significant statistical result pooled from retrospective studies.

Table 2.2 – Work related risk factors for neck pain in office workers

Variable	**Study**	**Strength Association (95% CI)**	***P* value**
Working without break	Kiss et al. 2012	OR:1.52, CI:1.18-1.97	p<0.001
	Cagnie et al. 2007	OR:2.79, CI:1.72-4.00	p<0.001
Mouse working hours	Kiss et al. 2012	OR:1.28, CI:1.12-1.97	p<0.001
Reaching distance for computer mouse (far vs close)	Kiss et al. 2012	OR:1.28, CI:1.12-1.46	p<0.001
Not enough space for computer mouse	Kiss et al. 2012	OR:1.77, CI:1.14-2.25	p<0.001
Forearm support >2/3 forearm	Kiss et al. 2012	OR:1.24, CI:1.10-1.41	p<0.001

Variable	Study	Strength Association (95% CI)	*P* value
Computer working hours	Kiss et al. 2012	OR:1.56, CI:1.20-2.03	*p*<0.001
	Juul-Kristensen and Jensen et al 2005	OR:1.53, CI:1.18-1.93	*p*=0.027
	Eltayeb et al. 2009	OR:1.2, CI:1.0-1.4	*p*=0.03
	Ranasinghe et al. 2011	OR:1.13, CI:0.99-1.27	*p*<0.05
	Piranveyseh et al. 2016	OR:3.34, CI:1.19-9.37	*p*=0.022
Separate wrist support	Kiss et al. 2012	OR:1.24, CI:1.04-1.50	*p*<0.05
Irregular head posture	Eltayeb et al. 2009	OR:1.1, CI:1.0-1.2	*p*=0.04
	Cagnie et al. 2007	OR:2.01, CI:1.20-3.38	*p*=0.008
Awkward body posture	Ranasinghe et al. 2011	OR:1.36, CI:1.13-1.23	*p*<0.05
Screen position relative to eye level	Jensen et al. 2003	OR: 1.5, CI:1.0-2.2	*p*=0.046
	Sihawong et al. 2015	OR:3.31, CI:1.10-10.02	*p*=0.03
Siting for a prolonged time	Cagnie et al. 2007	OR:2.06, CI:1.17-3.62	*p*=0.012
Same movements per minute	Cagnie et al. 2007	OR:1.63, CI:1.02-2.60	*p*=0.041
Work overload	Cagnie et al 2007	OR:1.71, CI:1.06-2.76	*p*<0.028
	Hagberg et al 2007	OR:1.7, CI:1.0-2.76	*p*<0.05
	Ranasinghe et al 2011	OR:1.11, CI:1.07-1.15	*p*<0.05

Abbreviations: OR - Odds ratio.

2.4.3 Psychosocial risk factors

The psychosocial factors are the workers subjective perceptions of the work organization. In this sense, the variable stress has been studied as much as the work-related risk factors. It can be caused by “high job strain” (Hannan et al., 2005; Hargberg et al., 2007; Harcombe et al., 2009), by “high job demands” (Hagberg et al., 2007; Eltayeb et al., 2009; Sihawong et al., 2016), with an association with neck pain. In the systematic review from Paksaichol et al. (2012), there was conflicting evidence from these two variables. Still, except for the studies from Eltayeb et al. (2009) and, of course, Sihawong et al. (2016), none of the mentioned studies were included.

Stress has also been linked with the sensation of muscle tension and "high muscle tension" as a risk factor for neck pain from prospective studies with a high risk ratio (RR: 2.75, CI: 1.60-4.72, p=0.0002) (Jun et al., 2017). The same for “somatization" as psychological distress by feeling neck pain (Harcombe et al., 2009; Oha et al., 2014), "work attribution beliefs" for the cause of neck pain as a negative emotion (Oha et al., 2014), "mental tiredness" at the end of the workday (Cagnie et al., 2007) and "high perceived exertion" which can be physical or emotional (Lindegärd et al., 2012).

Interestingly, psychosocial factors can be both a risk and a protective factor. In the case of office workers who reported “no job satisfaction” it can be a risk factor (RR: 1.28, CI: 1.07-1.55, p=0.008) (Jun et al., 2017), but a protective one if they seem to “be satisfied” (OR: 0.52, CI: 0.37-0.72, p<0.001) (Kiss et al., 2012). Another example is “feel support by the superiors at work” (OR: 0.80, CI: 0.70-0.92, p<0.001) (Kiss et al., 2012) as protective, or “no comfort at work” as a risk factor (Lindegärd et al., 2012; Jun et al., 2017) (table 2.3 and 2.4).

Table 2.3 – Psychosocial risk factors for neck pain in office workers

Variable	**Study**	**Strength Association (95% CI)**	***P* value**
Somatization	Oha et al. 2014	OR:2.65, CI:1.29–5.45	p<0.05
	Harcombe et al. 2009	OR:1.10, CI:1.04–1.16	p<0.001
Work attribution beliefs	Oha et al. 2014	OR:2.35, CI:1.18–4.69	p<0.05
High job demands	Sihawong et al. 2015	OR:1.16, CI:1.02-1.31	p=0.02
	Eltayeb et al. 2009	OR:1.2, CI:1.0-1.5	p=0.01
	Hagberg et al. 2007	OR:1.8, CI:1.0-3.0	p<0.05
Lack of social support	Ranasinghe et al. 2011	OR: 1.14, CI:1.09-1.19	p<0.05
High job strain	Harcombe et al. 2009	OR:3.46, CI:1.30–9.21	p<0.029
	Hagberg et al. 2007	OR:3.5, CI:1.36-8.83	p<0.05

Variable	**Study**	**Strength Association (95% CI)**	***P* value**
Mental tiredness at the end of the workday	Cagnie et al. 2007	OR:2.05, CI:1.29-3.26	p=0.003
Low influence at work	Jensen et al. 2003	OR: 2.2, CI:1.3-3.7	p=0.013
Depressed mood	Shahidi et al. 2015	OR: 3.36, CI:1.1-10.31	p=0.03

Abbreviations: OR - Odds ratio

Table 2.4 – Psychosocial hazard ratio and risk ratio for neck pain in office workers

Variable	**Study**	**Strength Association (95% CI)**	***P* value**
Psychological stress	Hush et al. 2009	HR:1.64, CI:0.66-4.07	p=0.042
High job strain	Hannan et al. 2005	HR: 1.65, CI:0.91-2.99	p<0.05
High perceived exertion	Lindegärd et al. 2012	RR:3.20, CI:2.31-4.38	p<0.05
Comfort at work	Lindegärd et al. 2012	RR:1.88, CI:1.28-2.76	p<0.05

Abbreviations: HR - Hazard ratio; RR- Risk ratio

2.5 Muscle strength in office workers with neck pain

The multifactorial risk factors developed or maintain neck pain. Also, physical risk measures, such as muscle strength, can cause neck pain. A recent study from Chen et al. (2018a), with a large sample size of office workers, did not find a reduced muscle strength in neck flexion and extension as a risk factor for neck pain in office workers. However, in office workers with CNP there was a decrease in maximal voluntary isometric contraction (MVC) in upper trapezius (UT) (Schulte et al., 2006; Sjøgaard et al., 2006; Andersen, L. L. et al., 2008; Nielsen et al., 2010; Bech et al., 2017), and cervical flexion and extension strength (Chen et al., 2018a), when compared with healthy office workers.

The trapezius muscle functions are to avoid compressive loads on the cervical spine, scapula movement, and at the same time, scapula stabilization (Johnson et al., 1994). The LT provides scapula stabilization during upward rotation, maintaining the horizontal and vertical equilibrium of the scapula (Johnson et al., 1994). However, it is still unknown the reason why office worker was less MVC in UT. There was no consensus about the increased electromyography activity of UT during computer work (Eijckelhof et al., 2013), and moderate evidence for no differences at rest or activities below the shoulder level between healthy and chronic workers (Castelein et al., 2015). Considering other variables that affect muscle strength, there was low evidence for differences in fiber type I and type II, and at least low to moderate evidence for no differences in the cross-sectional area of UT between trapezius myalgia and healthy controls (De Meulemeester et al., 2017). This needs further research. Nevertheless, there is a plausible rationale for the prescription of exercises focusing at least on the trapezius muscle.

Moreover, not much is known about the MVC in the middle and lower trapezius (LT) in office workers with CNP. In different populations with CNP, there was less MVC in middle trapezius but not in LT (Shahidi et al., 2012). This last finding contrasted in subjects with unilateral CNP with less MVC in LT (Petersen & Wyatt, 2011). In subjects with non-chronic unilateral neck pain there was less MVC in UT (Park et al., 2019), in LT and middle trapezius (Petersen et al., 2016; Park et al., 2019). Further research is needed to quantify MVC in LT.

2.6 Treatment effectiveness in office workers with neck pain

The conflicting results in the majority of the work-related risk factors can be explained by the variability between individuals, concerning mechanical forces (e.g. typing forces), posture, muscle activation even in performing the same task, mainly in idle activities, but also during keyboard and mouse working (Garza et al., 2012; 2014). Therefore, the pain complexity should be analysed with psychosocial factors to better understand the linking between computer work and musculoskeletal pain conditions (Madeleine et al., 2013). At this point, some questions needed to be asked. What was the treatment effectiveness for neck pain in this specific population? What were the modifiable factors included in the different treatment plans?

There are non-modifiable risk factors such as age, gender, "previous history of neck pain", "years of working on the computer". In addition, other factors are not to be changed under the responsibility of the healthcare, such as the "amount of time of working on the computer", "job satisfaction", "high job demands", "high job strain", and "work support" (O'Sullivan et al., 2016). However, there are modifiable factors as "work ergonomics", coping better with psychological distress, beliefs about work that may cause neck pain or beliefs of neck fragility (fear-avoidance beliefs), health comorbidities, lack of physical activity, and reduced cervical muscle strength and range of motion (O'Sullivan et al., 2016; Chen et al., 2018a). The role of ergonomic interventions and the strength exercises proven to be effective will be described below.

Therefore, for a treatment to be effective, it should address the possible modifiable factors. A recent systematic review and meta-analysis published by Cochrane Database of Systematic Reviews studied the effect of ergonomic interventions for preventing neck pain and upper limb disorders in office workers (Hoe et al., 2018). This review included 2166 office workers in 15 randomized controlled trials (RCT), and 14 out of 15 RCT had a high risk of bias. The main results were moderate quality evidence, that arm support with an alternative computer mouse reduced the incidence of neck pain (RR: 0.52, CI: 0.27-0.99), and low-quality evidence that reduced neck discomfort (SMD −0.34; 95% CI −0.63 to −0.06). There was moderate quality evidence for no changes in the incidence rate of neck pain when compared different types of mouse (RR: 0.91, CI: 0.48-1.72), low quality evidence for supplementary breaks in reducing neck discomfort (SMD −0.25; 95% CI −0.40 to −0.11), and low to very low quality evidence that active training interventions may or may not prevent neck disorders (Hoe et al., 2018). Those results were in line with previous Cochrane Systematic Reviews (Aas et al., 2011; Hoe et al., 2012). Another systematic review concluded low quality evidence that workplace interventions reduce neck pain in office workers (Chen et al., 2018b). Nevertheless, reducing the exposure factor is essential in rehabilitation, although it has also been proven not to be effective by itself.

Alongside ergonomic interventions, there was scientific research that studied the effectiveness of exercise in reducing neck pain in office workers. The question is, how is the effectiveness of exercise in reducing neck pain in office workers? The review from Sihawong et al. (2011) concludes heterogeneous results from exercise therapy in reducing neck pain in office workers, recommending either strengthening or endurance exercise to reduce neck pain and endurance exercise to reduce disability. Recently, a systematic review and meta-analysis conclude moderate quality evidence with a medium effect size that strengthening exercises were effective in decreasing CNP, provided that the exercises were directed at the neck/shoulder region (Chen et al., 2018b). Analysing this systematic review, there were possible forms of bias. A medium effect size was considered if the standardized mean difference (SMD) was between 0.5 and 0.8. The result in the meta-analysis was SMD: 0.59 (95%CI: 0.29-0.89, p=0.0001). However, the total weight was not 100%, meaning there was a missing study, which affected the final result due to the fact the SMD of the missing study was -0.08 (95% CI: -0.33-0.17). Another source of bias was the fact that three of the included studies were from one of the co-authors, and the analysis made was only possible assessing the raw data (Drucker et al., 2016).

Nevertheless, those systematic reviews demonstrated benefits in reducing neck pain in office workers and the intervention type with the best evidence level and effect size. Moreover, reduced muscle strength is a modifiable factor. In this sense, treatment must englobe strengthening exercises. The exercises included in the systematic review were dumbbell exercises (Viljanen et al., 2003; Blangsted et al., 2008; Andersen, L. L. et al., 2008; 2012), elastic tubing exercises (Andersen et al., 2011), and functional strengthen exercises (Andersen, C. H. et al., 2014). Interestingly, there was moderate evidence, just from one study, that strengthening exercise and individual physical therapy reduces neck pain with no difference between both interventions (Chen et al., 2018b).

About other forms of exercise, there was in this systematic review inconsistent evidence, with a small effect size (SMD:0.43, 95%CI:0.0-0.79, p=0.02) for general fitness exercise, from one trial a moderate evidence for whole-body light resistance exercise ($p<0.05$), and no difference for stretching exercise compared with no stretching (Chen et al., 2018b). However, from one good quality RCT, combining stretching exercise with endurance exercise with a one-year follow up reduces the neck pain incidence rate (HRadj=0.45, 95% CI 0.28-0.71) (Sihawong et al., 2014). Also, combining workplace ergonomic interventions and neck-specific exercise training reduces sickness absenteeism in office workers with neck pain (Pereira et al., 2019).

An analysis for the treatment compiled evidence for neck pain, there were some modifiable risk factors not encompassed, which can justify the effectiveness level (O`Sullivan et al., 2016; Lin et al., 2020). Besides, most of the included studies did not specify neck pain characteristics, and neck pain was unlike originating from the same sources (Sihawong et al., 2011). Thus, it is important to discuss the state of the art of neck classification and diagnosis.

2.7 Neck pain classification and diagnosis

The revised Neck Pain Clinical Practical Guidelines attributed C level evidence (weak evidence) in the diagnosis and classification of neck pain. This indicates how difficult an accurate diagnosis of the cause of pain is after the exclusion of a clear pathoanatomical cause (strong evidence) (Blanpied et al., 2017) (Table 2.5). The review from Parikh et al. (2019) included 46 Clinical Practical Guidelines for neck pain, concluding the majority focused on treatment guidelines with fewer numbers to recommend for the diagnosis of neck pain. The review from Blanpied et al. (2017) scored 6 out of 7 in this review and was one of the fewest with a diagnostic classification for CNP (Parikh et al., 2019).

Table 2.5 – Neck Pain Classification Categories (Blanpied et al. 2017)

Neck pain with mobility deficits
Neck pain with movement coordination impairments (including whiplash-associated disorder)
Neck pain with headaches (cervicogenic headache)
Neck pain with radiating pain (radicular)

Due to the fact, there is weak evidence for neck pain classification from a quality Clinical Practical Guideline, it is essential to analyse the classification used in office workers studies with CNP. The review from Larsson et al. (2007) proposed specific criteria for neck pain diagnosis (Table 2.6).

Table 2.6 - Criteria for neck pain diagnosis (Larsson et al 2007)

Diagnosis	**Criteria**
Tension Neck Syndrome	Neck pain; sense of fatigue or stiffness in the neck; pain radiating from the neck to the back of the head; tightness of muscles; tender spots in the muscles.
Cervical Syndrome	Pain radiating from the neck to the upper extremity; limited neck movement; radiating pain provoked by test movements; decreased sensibility in hands/fingers; muscle weakness of the upper limb
Cervicalgia	Neck pain, limited neck movement in at least four of six directions. Diagnosis only if tension neck syndrome or cervical syndrome is not present
Trapezius myalgia	Neck pain, tightness of muscles, tender points in the muscles. Diagnosis only if tension neck syndrome or cervical syndrome is not present

The majority of the mentioned studies defined non-specific neck pain. In the study from Brandt et al. (2004) with a sample size of 4548 office workers, the baseline prevalence of tension neck syndrome was 1.4%, and the one-year incidence rate was 0.2%. Hagberg et al.

(2007) performed 403 clinic examinations and classified neck pain in four diagnosis categories: "muscle disorder", "tendon disorder", "neuron disorder", and "joint disorder". The category with a higher average was "muscle disorder" with 34%, followed by "unclear" with 34%.
In fact, pain from muscle is a current problem in the neck region, being the UT, the muscle most affected and studied. The condition is named trapezius myalgia, becoming chronic trapezius myalgia when pain persists for more than three months. Its prevalence in elderly office workers was 38% (Juul-Kristensen et al., 2006), and Brandt et al. (2014) demonstrated a strong association between neck pain intensity and trapezius muscle tenderness in office workers. Some of the mentioned RCT with strengthening exercises included office workers with this condition (Andersen, L. L. et al., 2008; Nielsen et al., 2010; Søgaard et al., 2012; Andersen, C. H. et al., 2014).

The diagnosis criteria for trapezius myalgia is: (1) CNP mainly in UT muscle; (2) tightness of the trapezius muscle (i.e., a feeling of stiffness in the descending region of the trapezius muscle was reported by the subject at the examination of lateral flexion of the head); (3) tenderness on palpation of the UT muscle; (4) cervical spine was to have non-painful, normal or only slightly decreased range of motion (Juul-Kristensen et al., 2006). This last point is essential to differentiate from tension neck syndrome, defined with a decreased cervical range of motion in flexion, extension, or rotation (França et al., 2008).

However, in the majority of Clinical Practical Guidelines for neck pain, when there is no pathoanatomical cause, the classification is non-specific neck pain (Parikh et al., 2019). It can debatably be a cause for less effective treatment, mostly in cases of CNP. In this sense, the recent classification of International Classification of Diseases, 11th revision (ICD-11), attributes a new code system for chronic pain to primary care, defining it "as pain that recurs or persists longer than three months" (Smith et al., 2019). The chronicity causes neuroplastic changes, peripheral or central, being fundamental to recognize whether the underlying pain mechanism is nociceptive, neuropathic, nociplastic or a mixed pain, for a more accurate treatment management plan (Boudreau et al., 2010; Pavlakovic & Petzke, 2010; Arendt-Nielsen et al., 2011; Pelletier et al., 2015; Chimenti et al., 2018; Freynhagen et al., 2019).

2.8 Nociplastic pain

The definition of nociplastic pain, accordingly with International Association for the Study of Pain (IASP) is "pain that arises from altered nociception despite no clear evidence of actual or threatened tissue damage causing the activation of peripheral nociceptors or evidence for disease or lesion of the somatosensory system causing the pain", and "patients can have a combination of nociceptive and nociplastic pain" (Loeser et al., 2011). Moreover, nociplastic pain is not a diagnosis, it refers to all individuals in whom altered nociception can be demonstrated, and it should be systematically screened-in cases of chronic pain. In a nociplastic pain, central sensitisation is an inference as an underlying mechanism, as in neuropathic pain, the underlying mechanism is a nerve lesion (Kosek et al., 2016; Trouvin & Perrot, 2019). Central sensitization is defined by IASP "an increased responsiveness of nociceptive neurons in the central nervous system to their normal or subthreshold afferent input" (Loeser et al., 2011).

This altered nociceptive processing can be assessed through quantitative sensory tests (QST) (Kosek et al., 2016). There is some evidence that office workers with more severe chronic pain on the neck demonstrate signals of central sensitization through QST (Johnston et al., 2008; Ge et al., 2014). The implied neuroplastic changes in the nervous system can also occur in the peripheral nervous system, in the central nervous system or both at the same time (Pavlakovic & Petzke, 2010; Pelletier et al., 2015).

QST is a possible method to address those changes in the nervous system, namely PPT, TSP and CPM:

a) Pressure pain threshold (PPT) defined as the minimum value for distinguishing mechanical pressure from a first painful pressure assessed by an algometer which is a valid and reliable measurement tool for PPT in the neck region (Walton et al., 2011, 2014; Zamani et al., 2017). PPT assessed in different regions, in a painful area and in a distal non-painful area, can differentiate and quantify localized muscle hyperalgesia (peripheral sensitization) from widespread hyperalgesia (central sensitization) (Arendt-Nielsen et al., 2011, 2018).
b) In pain conditions, the wide dynamic range neurons in the dorsal horn of the spinal cord increase their receptive field size, originating secondary hyperalgesia, allodynia and widespread pain. Temporal summation of pain (TSP), which applies a stimulus with the same intensity and frequency for a short period, is the experimental method to assess the wind-up process reflecting dorsal horn excitability (Latremoliere & Woolf, 2009; Pelletier et al., 2015; Arendt-Nielsen et al., 2018).
c) Descending inhibitory and excitatory pathways from the brainstem, mainly from the Periaqueductal Gray-Rostral ventromedial medulla system (PAG-RVM), inhibits the C-fiber nociception transmission from the superficial dorsal horn to the deep dorsal horn in the spinal cord, and in cases of chronic pain can inclusively amplify this

transmission (Heinricher et al., 2009; Pelletier et al., 2015). Conditioned pain modulation (CPM) is used to test the inhibitory pain mechanism. A systematic review and meta-analysis revealed an impairment in the inhibitory system in chronic conditions (Lewis et al., 2012).

The PAG-RVM received input from the cingulate cortex, hypothalamus, amygdala and medial prefrontal cortex, contributing to pain inhibition or facilitation (Heinricher et al., 2009). Those brain areas are responsible for the cognitive and affective symptoms of chronic pain, such as fear, decreased attention, emotions, catastrophizing, and negative feelings (Pelletier et al., 2015). Different types of questionnaires quantify those self-reported symptoms, which can be related to QST findings. Psychological factors, such as depression and pain catastrophizing, are often associated with pain and pain progression. Recently, widespread hyperalgesia was associated with depression scores in chronic pain patients (Kato et al., 2017). Also, a weak correlation between pain catastrophizing with PPTs has been found in CNP (Walton et al., 2014), being necessary further studies.

Step up an important point, central sensitization can be perpetuated by peripheral mechanisms. As mentioned, chronic trapezius myalgia is one of the conditions causing neck pain in office workers, and chronic pain in chronic trapezius myalgia suggest central sensitization (Sjörs et al., 2011). Several experiments studied the inflammatory mediators in trapezius myalgia, measuring an increasing concentration of lactate, pyruvate (Rosendal et al., 2004; Sjøgaard et al. 2010), potassium, interleukin-6 (Rosendal et al., 2005; Shah et al. 2008), glutamate and serotonin (Rosendal et al. 2004, Shah et al. 2005, Shah et al. 2008), substance P (Shah et al., 2005; Shah et al., 2008), bradykinin (Gerdle et al., 2008) not only at baseline measures, but their concentration also increases more than healthy individuals performing the same tasks (Rosendal et al., 2004; Gerdle et al., 2008). Mediators such glutamate, substance P, calcitonin gene-related peptides, and bradykinin in particular, constantly depolarize *N*-methyl-D-aspartate receptors (NMDA), and pain physiology research indicated the excitability of the NMDA receptor is crucial for central sensitization and persistent pain states (Petrenko et al., 2003; D'Mello & Dickenson, 2008; Latremoliere & Woolf, 2009; Woolf 2011).

Therefore, for an optimization treatment strategy, it is crucial for office workers with CNP to classify the pain mechanism and cross-reference with the modifiable risk factors that can perpetuate the pain experience. Moreover, recent systematic reviews mentioned a lack of studies addressing central sensitization in idiopathic chronic non-traumatic neck pain, and a homogeneous population is needed to quantify in CNP, mainly TSP (Malfliet et al., 2015; Georgopoulos et al., 2019).

2.9 Dissertation aims

The present dissertation aims to investigate central sensitization in office workers with chronic neck pain, comparing the differences between pain conditions with pain intensities.

Chapter 4 is a systematic review and meta-analysis aiming to compare PPT values between office workers with CNP and asymptomatic office workers (CON). The second aim was to provide normative PPT values in office workers with CNP. A third objective was to investigate the strength of association between PPT values with pain intensity and disability in office workers with CNP.

Chapter 5 is a cross-sectional observational, descriptive and correlational study aiming to study the prevalence of musculoskeletal pain in Portuguese office workers and to identify occupational factors related to neck pain.

Article 3 and 4 are cross-sectional observational, analytic and correlational studies. In **Chapter 6**, the primary aim was to assess PPTs, TSP, and CPM in office workers with chronic trapezius myalgia, chronic nonspecific neck pain, and asymptomatic subjects. Also, office workers with different pain intensities (mild, moderate and no pain) were assessed. The second aim was to investigate associations between clinical pain intensities and disability with pain catastrophizing, psychological factors and quantitative sensory tests.

In **Chapter 7**, the aim was to assess MVC in UT and LT in office workers, comparing different conditions and pain intensities. The second aim was to investigate the associations between the ratio UT/LT, pain intensity and pain sensitivity measures (pressure pain threshold and temporal summation of pain) in UT and LT MVC.

In **Chapter 8,** the primary aim was to assess sensitization through QST findings in individual office workers with chronic neck pain. The second aim was to assess the differences between the number of individual QST findings with pain intensity and catastrophizing.

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3

Methodology

3 Methodology

3.1 Studies Overview

This chapter contains a brief description of the methodology involving the five articles of this thesis. The protocols presented in this thesis were approved by the Faculty of Human Kinetics - University of Lisbon Ethics Committee (Approval Number:23/2017) and conducted according to the Declaration of Helsinki.

In Article 1, the systematic review and meta-analysis was registered at PROSPERO with the number CRD42020164521 and described in chapter 4. The cross-sectional observational, descriptive and correlational study (article 2) consisted of an online questionnaire (Appendix V) which was the basis for office worker recruitment for the subsequent studies. Office workers were invited based on inclusion and exclusion criteria full described in chapter 5 and 6. Afterwards, a standard clinic examination was performed, by one examiner with more than 15 years of clinic experience, to ensure that the subjects met the above criteria (fig 1).

Articles 3, 4 and 5 (chapter 6, 7, and 8) were the core studies of this thesis.

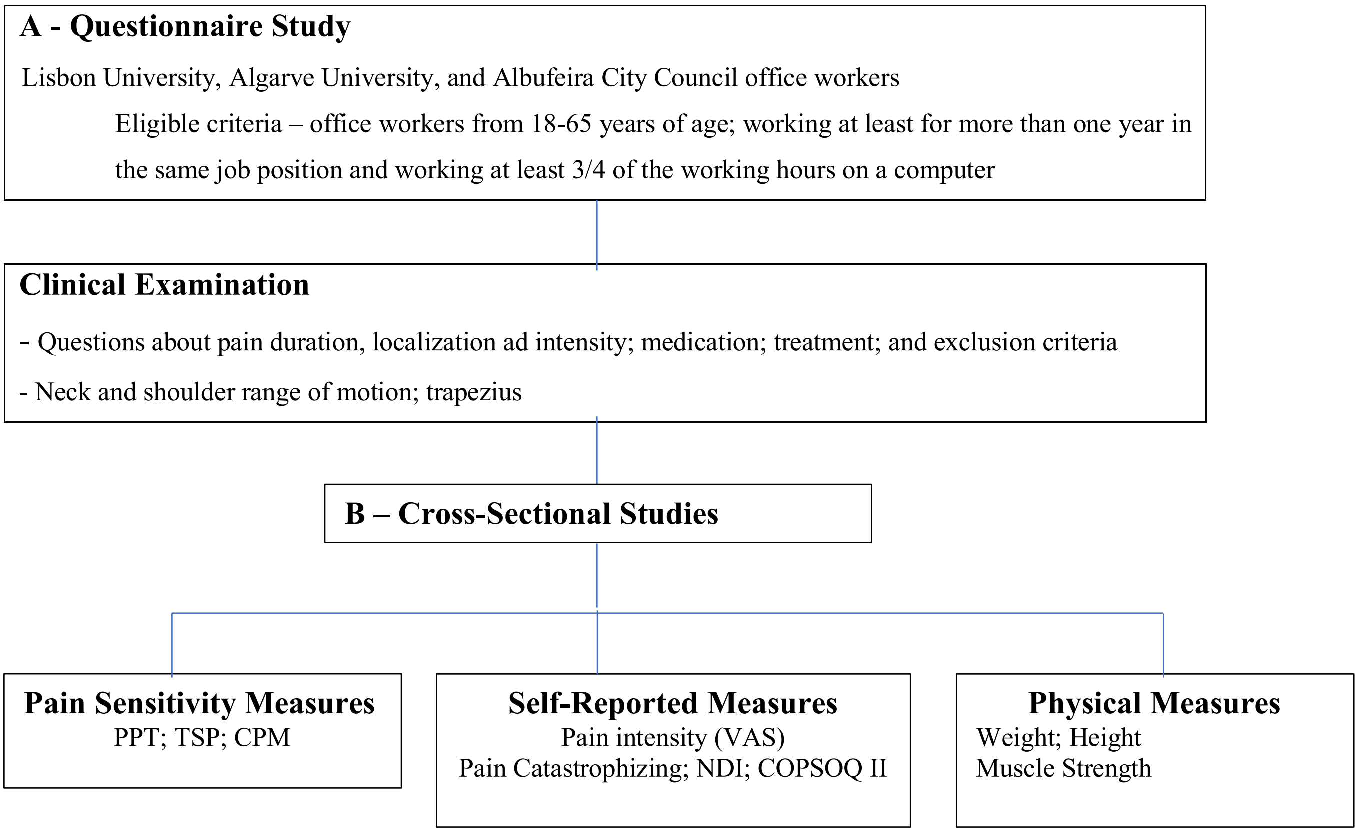

Figure 3.1 – Flow Chart

3.1 Measurement

The measurements were conducted in three different places accordingly, where the office workers were recruited. These distinct areas, plus office workers schedule, a long period of the measurements did not allow to have a fixed hour of the day, day in the week, as well as the same period of the year for data collection for all office workers. Clearly, it might be different to measure some of the variables at the outset of the week/day of work. These were considered limitations of this thesis.

Table 3.1 summarizes the main methodological procedures of articles 3, 4 and 5. Tables 3.2 to 3.6 described the measurements procedures conducted in these articles.

Table 3 1 – Summary of the main procedures

Design	Office Workers Sample (N) Male / Female	Statistical Analysis	Variables		
			Pain sensitivity measures	Self-Reported Measures	Physical Measures
Article 1					
Systematic Review and Meta-analysis	13 studies 692 92 / 600	Meta-analysis	PPT (kPa)	VAS (0-10) NPRS (0-10) NDI	NA
Article 2					
Cross-sectional observational, descriptive and correlational study	601 165 / 436	Univariate and multivariate logistic regression analysis	NA	Standardized Nordic Musculoskeletal Questionnaire Appendix V	NA
Article 3					
Cross-sectional observational, analytic and correlational study	171 36 / 135	ANOVA, ANCOVA Pearson's correlation Stepwise multiple linear regression analysis	PPT (kPa) TSP (VAS-0-10) CPM [PPT (kPa)]	VAS (0-10) NDI PCS COPSOQ - II	Weight (kg) Height (cm)
Article 4					
Cross-sectional observational, analytic and correlational study	133 0 / 133	ANOVA ANCOVA Univariate regression analyses Stepwise multiple linear regression analysis	PPT (kPa) TSP (VAS-0-10)	VAS (0-10) COPSOQ - II	Weight (kg) Height (cm) UT MVC LT MVC

Design	Office Workers Sample (N) Male / Female	Statistical Analysis	Variables		
			Pain sensitivity measures	Self-Reported Measures	Physical Measures
Article 5					
Cross-sectional observational, analytic and correlational study	104 11 / 93	ANOVA Pearson's chi-squared test	PPT (kPa) TSP (VAS-0-10) CPM [PPT (kPa)]	VAS (0-10) PCS	Weight (kg) Height (cm)

Abbreviations: COPSOQ II = Copenhagen Psychosocial Questionnaire II; CPM = Conditioned Pain Modulation; MVC= maximum voluntary contraction; LT = lower trapezius; NA – not attribute; NDI= Neck Disability Index; PCS= Pain Catastrophizing Scale; PPT= Pressure Pain Threshold; TSP= Temporal Summation of Pain; VAS = Visual Analogue Scale; UT = upper trapezius.

Table 3.2 –Pressure Pain Threshold

PPT Point	Patient Position	Material	Measurement Procedure	
			General	Specific
UT (both points)	Prone	-Hand-held pressure Algometer with 1 cm^2 rubber tip applicator (JTech -Medical, Salt Lake City, USA) -Pencil marker -Goniometer - Measurement Tape	- Defined as the minimum pressure first evoking a pain sensation. - Application Rate 1.0 kgF/s - Upper cut-off limit of 500 kPa - Two measurement with 10 seconds interval	Localized in the midpoint between C7 and acromion
ECU	Supine			Lateral epicondyle: 40 mm inferior in a vertical line and then 20 mm posterior
TA	Supine			Approximately 2.5 cm lateral and 5 cm inferior to the tibial tubercle

Abbreviations: ECU = extensor carpi ulnaris; UT = upper trapezius; TA = tibialis anterior.

Table 3.3 –Temporal Summation of Pain

	Patient Position	Material	Measurement Procedure
TSP	Sitting	- von Frey stimulator (Aalborg University, Aalborg, Denmark), with a weighted load of 25.6 g - Visual Analogue Scale	- UT point - Localized in the midpoint between C7 and acromion -10 consecutive stimulations with a 1-second interval between stimulations. - TSP is difference in pain intensity between the first and the last stimuli (Petersen et al. 2015)

Abbreviations: TSP= Temporal Summation of Pain; UT = upper trapezius.

Table 3.4 –Conditioned Pain Modulation

	Patient Position	Material	Measurement Procedure
CPM	Sitting and prone	- Hand-held pressure Algometer with 1 cm^2 rubber tip applicator (JTech -Medical, Salt Lake City, USA) - Visual Analogue Scale - Cold water bath maintained at 2 to 3ºC - Thermometer - Chronometer	- PPT - UT point before and after the cold pressor test - Contralateral hand of the painful side/dominant side immersed up to the wrist crease during 2 minutes or to remove the hand when a pain intensity of 7 out of 10. -Hand immersed time - Pain intensity caused by the cold water

Abbreviations: CPM = Conditioned Pain Modulation; PPT= Pressure Pain Threshold; UT = upper trapezius.

Table 3.5 - Self-Reported Measures

Scale	Constructs	Dimensions	Questions	Scoring	Total score	Interpretation	Time
NDI	Disability	Pain intensity, Personal Care, Lifting, Reading Headaches, Concentration, Work, Driving Sleeping, Recreation	10	Likert Scale 0-5 0 – no disability 5 – complete disability	0-50	Higher scores mean more disability.	5 min
COPSOQ II	Health and well-being	Burnout, Stress Sleeping Troubles, Depressive symptoms, Somatic stress, Cognitive stress	26	Likert Scale 0-5 0 – not at all 5 – all the time	Scores calculated as an average of the items included	Higher scores mean more health and well-being problems	10 min
PCS	Pain catastrophizing	Rumination Magnification Helplessness	13	Likert Scale 0-4 0 – not at all 4 – all the time	0-52	>30 clinically relevant level of catastrophizing	5 min

Abbreviations: COPSOQ II = Copenhagen Psychosocial Questionnaire II; NDI= Neck Disability Index; PCS= Pain Catastrophizing Scale.

Table 3.6 – Upper and lower trapezius muscle strength

Muscle	Patient Position	Material	Measurement Procedure	
			General	**Specific**
Upper Trapezius	Sitting position with their feet flat on the floor.	-Hand-held dynamometer (HDD) (Lafayette Manuel Muscle Test System Model 01163, Lafayette Instrument Co., NL, USA) - Goniometer	-Scapula in a neutral position. -A "make test" procedure -Three MVC with a minimum of 60s rest between each repetition. -Average from the three repetitions was used for data analysis. -After the first HDD beep, to slowly and progressively produce muscle contraction for the first 2 seconds and to reach maximum strength until the 5 seconds, and to stop completely after the second HDD beep. -The HDD strength values in Newton (N) were normalized to body weight (recalculated to Newton).	-HDD placed over the superior part of the acromion -The movement was a shoulder-shrugging.
Lower Trapezius	Prone			-Arm in 145º of abduction with the thumb pointing up (external rotation). -HDD placed on the distal radial styloid process.

Abbreviations: HDD = Hand-held dynamometer; MVC= maximum voluntary contraction.

3.2 Data analysis

In the systematic review and meta-analysis, all the analyses used the random-effects model with three approaches (Borenstein et al., 2009). Full details in chapter 4.

Descriptive statistics were used to describe subject characteristics, and the Shapiro-Wilk test was used to assess normality.

Article 2 used multivariate logistic regression analysis. Univariate logistic regression was used to calculate the odds ratio and their 95% confidence intervals for the presence of neck pain for each occupational factor, and those with a p-value of <0.20 were introduced in the multivariate logistic regression analysis.

Articles 3, 4 and 5 included three groups (two symptomatic groups and one asymptomatic group). An ANOVA was used to analyse the differences between the three groups. An Unpaired t-test was used for the differences in the symptomatic groups.

In article 3, an ANCOVA was used with gender as a covariate to analyse the differences between groups in PPT, TSP and CPM. A multiple linear regression analysis was used to categorize independent parameters for pain intensity and disability from the Pearson's product-moment correlation.

In article 4, the covariates were age and pain intensity at present-day to detect UT and LT MVC differences. A multiple linear regression analysis was conduct with the significant independent variables results from the univariate analyses to investigate the relationship between the dependent variables (strength) and independent variables. Strength values were normalized to body weight (N) (Hurd et al., 2011).

In article 5 was conducted a simple analysis. A Pearson's chi-squared test was used to determine whether there was a statistical difference between the average of the three QST tests in QST1 and QST 2. Details in chapter 8.

All meta-analytic procedures were conducted using the RevMan software program for Macintosh (The Cochrane Collaboration, 2014). The other statistical analysis was conducted using SPSS 25.0 software (SPSS Inc., Chicago, IL, USA). Significance was established at a level of 5%.

3.3 Reference List

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4

Pressure pain thresholds in office workers with chronic neck pain. A systematic review and meta-analysis[1]

[1] Nunes, A., Moita, J., Espanha, M., Arendt-Nielsen, L., Petersen, K. (2020). Pressure pain thresholds in office workers with chronic neck pain. A systematic review and meta-analysis. Pain Practice, 2021.

4.1 Introduction

Neck pain is a highly prevalent health problem in the general population and one of the leading causes of global disability amongst the working population (Côte et al., 2008; Hoe et al., 2014; Vos et al., 2016). The annual prevalence rates range between 30-50% (Côte et al., 2008), with office workers (OW) with chronic pain neck pain (CNP) ranging up to 40% (Janwantanakul et al., 2008; Madeleine et al., 2013).

The underlying reasons for chronic pain are largely unclear. The assessment of subjective pain should be made through pain scales, patient complaints, and quantitative sensory tests (Kumar 2007). Pressure pain threshold (PPT) by algometry is used as a validated and reliable measurement tool for pain sensitivity assessment in the neck region (Walton et al., 2011, 2014; .Zamani et al., 2016). PPTs assessed in a localized pain area can reflect localized hyperalgesia whereas PPTs assessed in areas remote to the painful region reflect widespread hyperalgesia (Arendt-Nielsen et al. 2011, 2018). Normative cut-off points reference values corresponding to 10^{th} and 25^{th} percentile from the mean in free-pain population has been proposed as a lower PPT limit value to be considered as hypersensitive and 75^{th} and 90^{th} percentile to be the upper PPT limit to be considered as hyposensitive (Neziri et al., 2011; Waller et al., 2016).

Widespread hyperalgesia can be a component of central sensitization (Graven-Nielsen & Arendt-Nielsen 2010), and has been found to be predictive for development of chronic postoperative pain (Wylde et al., 2013; Petersen et al., 2016), neck pain associated with whiplash-associated disorders (Wallin et al., 2012; Stone et al., 2013), and in chronic non-specific neck pain (La Touce et al., 2010; Johnston et al., 2008). In addition, widespread hyperalgesia has been observed in office workers with CNP with high pain and disability compared to office workers with low pain and healthy workers (Johnston et al., 2008; Ge et al., 2014). However, those conclusions were made from a control group without OW [20] and from small sample size in the asymptomatic OW group (Ge et al., 2014).
It remains unclear if PPTs can be meaningful in clinical practice to profile and characterize patients with CNP. To our knowledge, this is the first systematic review addressing this topic in CNP in a specific population.

The aims of systematic review were to: 1) compare PPTs values between office workers with chronic neck pain (CNP) and asymptomatic control office workers (CON); 2) establish reference PPTs values in CNP; 3) investigate the strength of association between PPTs values with pain intensity and disability in CNP.

4.2 Methods

The review protocol was registered a priori at the International Prospective Register of Systematic Reviews (registration number: CDR42020164521). This systematic review and meta-analysis are reported according to the PRISMA guidelines (Moher et al., 2015).

4.2.1 Eligibility Criteria

Studies were considered for inclusion if they investigated: (1) adult office workers or computer workers (age > 18); (2) a group with non-specific chronic neck pain (CNP); (3) PPT as one of the main outcomes; (4) and studies written in English and Portuguese. CNP is defined as a condition where pain persists for more than three months (Furlan et al., 2009; Smith et al., 2019), isolated to neck/shoulder area without any know cause, and is provoked by maintained neck postures, neck movements, or palpation of the cervical musculature (La Touche et al., 2010; Hoe et al., 2014). PPT is defined as the minimum amount of pressure that elicits a painful sensation to pressure.

Review studies (systematic and narrative) were excluded after having their reference lists examined in order to identify appropriate studies for inclusion. Studies not meeting the inclusion criteria were excluded and/or if they present one or more of the following exclusion criteria : (1) no clear indication of pain duration to be considered chronic definition; (2) not controlling for medical history of cardiovascular diseases, major chronic diseases, a medical diagnosis of fibromyalgia, rheumatoid arthritis or other auto-immune systemic diseases, cervical disc herniation or severe disorders of the cervical spine, whiplash, injury, other existing neurologic and/or metabolic diseases (Søgaard et al., 2012); (3) non-original research, conference proceedings, and doctoral theses; (4) when data was lacking or not clearly described.

4.2.2 Information Sources and Search Strategy

Two reviewers (AN, JM) created and ran a systematic search of literature on seven databases (PubMed, EBSCO, PEDro, SCIELO, Web of Science, SCOPUS, Cochrane Library) from database inception until 26th March 2019, using the following key terms: office worker, neck pain, pressure pain threshold and algometry (appendix 1 for full search strategy).

4.2.3 Study Selection

The reviewers (AN, JM), using the predetermined search strategy, independently scanned for potentially relevant articles. References were imported to RefWorks and duplicates removed. After removal, the studies suitable for review through the inclusion and exclusion criteria, were retrieved for in-depth analysis. A consensus meeting with a third party (ME) was held if the reviewers were not able to reach an agreement on the inclusion of a study. Corresponding authors of original studies were contacted in an attempt to obtain extra information if necessary.

4.2.4 Data Collection Process

The following data were extracted: (1) authors and year of publication; (2) study design; (3) office worker group characteristics (number, age, and gender); (4) type of algometer and measurement; (5) PPT location(s) in neck area and non-neck area; (6) outcomes were PPT, pain intensity and disability. After, data were independently checked by a second reviewer.

4.2.5 Risk of Bias in Individual Studies

Risk of bias was assessed independently by two reviewers (xx and xx), using the same process described recently (Moita et al., 2017). Briefly, the same reviewers used the Downs and Black checklist, which is a methodological quality assessment tool shown to have a high internal consistency (KR-20 = 0.89), good test–retest reliability (r = 0.88) and good interrater reliability (r = 0.75) (Downs & Black 1998). It consists of 27 items across five sections, as follows: (i) Study quality (10 items) –the overall quality of the study based on data reporting; (ii) External validity (3 items) – the ability to generalize findings of the study through their representativeness; (iii) Internal validity concerning study bias (7 items) – to assess bias in the intervention and outcome measure(s); (iv) Internal validity concerning confounding and selection bias (6 items) – to determine bias from sampling or group assignment; and (v) Power of the study (1 item) – to determine if findings are due to chance (for more information see Appendix 2).

Due to some heterogeneity in the included studies design, the checklist was modified. From the original 27 items, 12 items were not applied to the observational studies (4, 8, 9, 13–15, 17, 19, 23–24, 26–27) as they relate specifically to intervention studies, and items 5, 21 and 22 were omitted for studies that did not provide an independent control group. Accordingly, and taking into account the variation of the total item numbers of the checklist, the quality assessment results are presented as percentage scores, as previously suggested (Butterworth et al., 2012). The strength of agreement between reviewers was determined through Cohen's kappa (Cohen 1998). Interpretation of Kappa values was established using standards proposed by Landis & Koch (1977): 0=poor, 0.01–0.20=slight, 0.21–0.40=fair, 0.41–0.60=moderate, 0.61–0.80=substantial, and 0.81–1=almost perfect.

4.2.6 Data Analysis

The PPTs results were reported through means, 95% CI, standard deviations, and p-value. We summarized all mean PPT points values in the selected studies. Normally, PPTs measurements are reported in kg/cm^2 or kPa, and for consistency, all scores are converted to kPa.

Studies were grouped based on study design, and PPT protocol (same PPTs assessment areas) and further clustered according to pain intensity and disability. If a cluster contained at least two studies reporting means and standard deviation, a meta-analysis was conducted. All analyses used the random-effects model because of the possibility of confounding variables (i.e. age, gender, pain intensity, pain duration) within the inclusion criteria (Borenstein et al., 2009).

Duo to the design variability of the included studies, the following meta-analysis approaches were used: a) the baseline mean difference (MD) 95% CI for the same PPT was calculated based on the differences between CNP and CON, where a negative value demonstrates a lower PPT in CNP, and a positive value demonstrates a higher PPT in CON; b) one-arm meta-analysis of the baseline PPT values from CNP groups were employed, in which all studies (RCT, cross-sectional, Cohort) that presented the same PPT assessment area mean value and standard deviations (converted to standard error (SE)) were included (Rosa et al., 2019). For studies with more than one group, the PPT scores were combined according to the formula in appendix 3 (Higgins & Green 2011); c) associations between PPT with pain intensity and disability were determined through the Pearson product-moment correlation coefficient (r-$value$) when reported. R-values from the different studies were pooled using "Fisher's z' transformation" (i.e. z-transformed r value) using the following formula: $z'=0.5[\ln(1+r)-\ln(1-r)]$ where ln is the natural logarithm (Kenny 1987). Also, the included studies were weighted according to the magnitude of the respective standard error (SE.) The formula used to calculate the SE was: $SE = 1/\sqrt{N-3}$: where N refers to the number of pairs of scores (Kenny 1987). For the classification and interpretation of correlation sizes, r_z-values were back-transformed to *r*-values, and interpreted according to the recommendation of Vicent (1995), values of $0 \leq r \geq 0.69$ indicate small, $0.70 \leq r \geq 0.89$ indicate moderate and $r \geq 0.90$ indicate large correlation sizes (Muehlbauer et al., 2015; Kiss et al., 2018).

Studies not included in the meta-analysis were described separately. Heterogeneity was assessed using I^2. For the interpretation of the I^2 values the following classification was used: 0%-40% might not be important; 30%-60% moderate; 50%-90% substantial heterogeneity; 75%-100% considerable heterogeneity (Higgins & Green 2011). If heterogeneity was higher than 60% with more than three studies, a subgroup analysis was conducted according to Downs and Black score, excluding studies with scores below average (Bandt et al., 2019).

All meta-analytic procedures were conducted using the RevMan software program for Macintosh (RevMan 2014), and all results were presented in a forest plot. The reliability of the risk of bias assessment scores between the two assessors was examined by k Statistics using SPSS V.25 software (IBM 2017).

4.3 Results

4.3.1 Study Selection

Figure 4.1 presents the Flowchart describing the selection process and reasons for exclusion. A total of 315 studies were identified through electronic data base search. After duplicates removal (n=93), 222 studies were screened in title and abstract for eligibility criteria, out of which 187 were excluded, and 36 retrieved for in-depth analysis. From those, 12 manuscripts met the inclusion criteria and one additional study identified by hand search of the reference list. A total of 13 manuscripts were considered eligible for review (He et al., 2004; Johnston et al., 2008, 2009; Kimura et al., 2008; Nielsen et al., 2010; Andersen L. et al., 2012; Andersen C. H. et al., 2014; Ge et al., 2014; Shahidi et al., 2015; Bragatto et al., 2016; Shahidi & Maluf 2017; Heredia-Rizo et al., 2019; Valera-Calero et al., 2019).

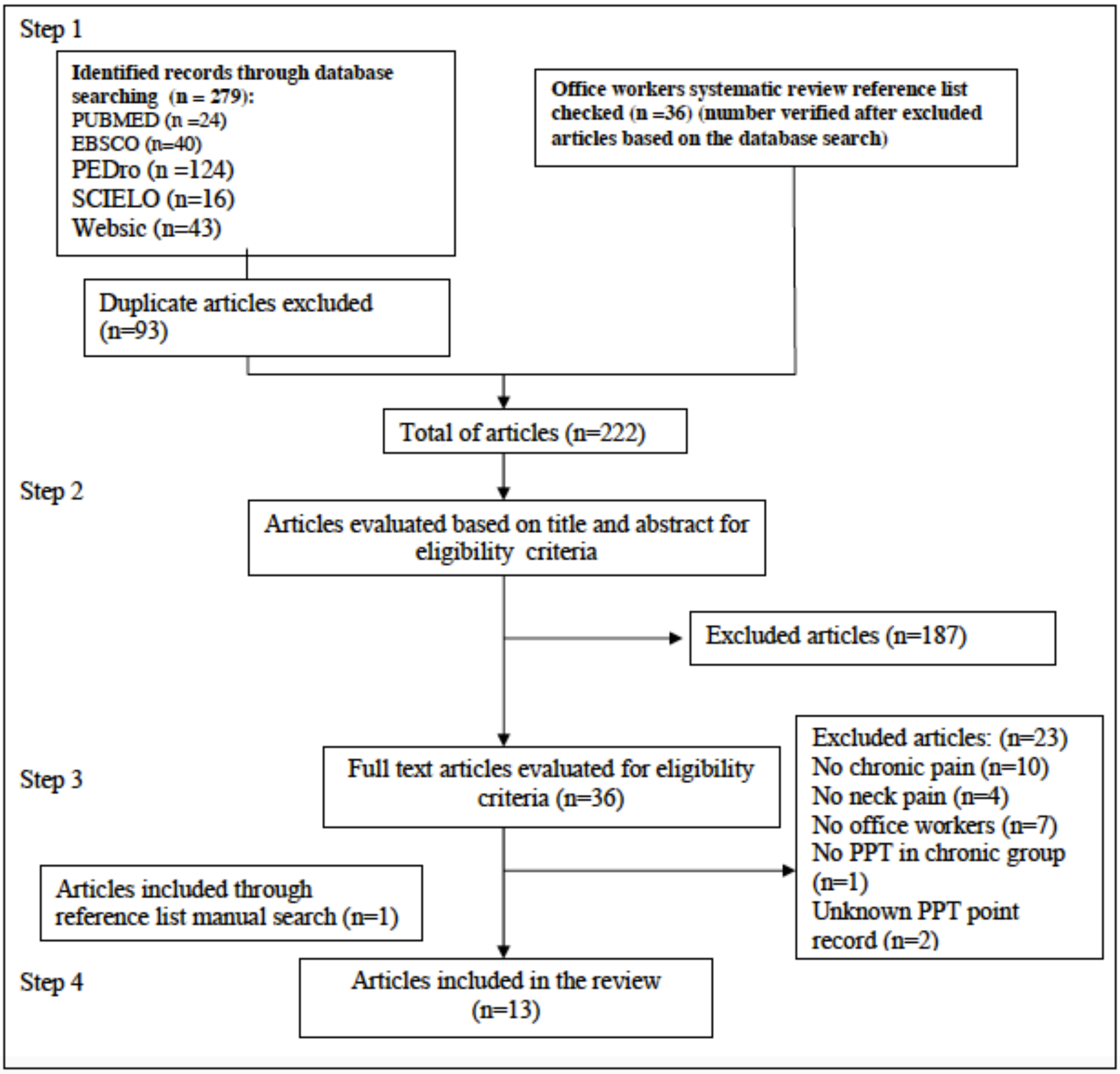


Figure 4.1 - Flow diagram for selection articles included in the review.

For meta-analytic purposes, the corresponding authors of eight publications (six authors) were contacted with the request to provide information on additional data. Three authors responded and delivered the request information, one of the authors did not retrieve the full data required, and two did not respond.

4.3.2 Study Characteristics

Table 4.1 shows the characteristics and a summary of the findings of all studies included in this review. The 13 studies included consisted of 4 cross-sectional studies (Johnston et al., 2008, 2009; Ge et al., 2014; Bragatto et al., 2016), 2 prospective cohort studies (Shahidi et al., 2015; Shahidi & Maluf 2017,4 randomized controlled trials (RCT) (He et al., 2004; Andersen

L. et al., 2012; Andersen C. H. et al., 2014; Valera-Calero et al., 2019), 2 studies with a mixed design (Part A, a cross-sectional and part B an RCT) (Nielsen et al., 2010; Heredia-Rizo et al., 2019), and 1 uncontrolled trial (Kimura et al., 2008). A total of 692 office workers (92 males/600 females), from those 609 were CNP (87 males/522 females) and 83 were CON (5 males/78 females).

All the studies measured PPT in the neck region, and seven studies measured PPT in non-neck areas (Johnston et al., 2008, 2009; Nielsen et al., 2010; Andersen L. et al., 2012; Andersen C. H. et al., 2014; Ge et al., 2014; Heredia-Rizo et al., 2019). The most common PPT assessment area in the neck region were: a) the upper trapezius defined the midpoint between C7 and acromion in 12 studies (He et al., 2004; Johnston et al., 2008, 2009; Kimura et al., 2008; Nielsen et al., 2010; Andersen L. et al., 2012; Andersen C. H. et al., 2014; Ge et al., 2014; Shahidi et al., 2015; Bragatto et al., 2016; Shahidi & Maluf 2017; Heredia-Rizo et al., 2019).b) the levator scapulae point (LS) in 3 studies (He et al., 2004; Johnston et al., 2008, 2009) c) the suboccipital point in 2 studies (He et al., 2004; Bragatto et al., 2016); d) the semispinalis muscle in the posterior neck in 2 studies (He et al., 2004; Bragatto et al., 2016);

Table 4.1 – Study characteristics

Author/ year of publication	Study Design	Population		Device and measurement		PPT Location(s)		Outcomes			R
		CNP **N** **Age** **Gender (M/F)**	**CON** **N** **Age** **Gender (M/F)**	**Electronic / mechanical**	**Probe size / rate/ outcome**	**Neck area**	**Non-neck area**	**PPT kPa Mean±SD**	**Pain Intensity**	**NDI**	
Andersen et al. (2012)	RCT	**Group 1** n=66 44±11 8/58 **Group 2** n=66 42±11 8/58 **Group 3** n=66 43±10 8/58		Electronic pressure algometer (Wagner Instruments, Greenwich, CT, USA)	1cm^2 30 KPa.s^{-1} kPa	**UT** Midpoint between C7 and acromion	**TA** Midway between the lateral condyle of the tibia and the lateral malleolus of the fibula	**UT** Group 1 239±92 Group 2 260±108 Group 3 219±73 **TA** Group 1 329±124 Group 2 331±127 Group 3 309±120	**VAS (0-10)** (3 months) Group 1 5.2±1.9 Group 2 5.2±2.1 Group 3 4.5±1.9	NA	**PPT between UT and TA** r=.60

Andersen et al. (2014)	RCT	**Group 1** n=23 45±11 5/18 **Group 2** n=24 44±13 5/19		Electronic Pressure Algometer (Algometer Type 2; Somedic, Horby, Sweden)	1cm^2 30 KPa.s^{-1} kPa	**UT** Midpoint between C7 and acromion **LT** 2/3 down between angulus superior and the spinal attachment	**Sternum** Middle part **TA** muscle belly	**UT** Group 1 303±127 Group 2 277±155 **LT** Group 1 383±145 Group 2 308±161 **Sternum** Group 1 254±154 Group 2 225±128 **TA** Group 1 381±135 Group 2 321±93	**VAS (0-9) (last month)** Group 1 5.4±1.5 Group 2 5.7±1.9	NA	NA

Bragatto et al. (2016)	Cross-sectional	n=26 36.5 (33-4-36.6) (0/26)	n=26 33.81 (30.6 - 36.9) (0/26)	Digital Dynamometer model DDK-20	NA 0.5 Kg /cm²s¹ Kg/cm²	**UT** midpoint between C7 and acromion **ECM** Insertion fibers below the mastoid process **Suboccipital**Point immediately below the mastoid process	NA	**UT** CNP 183±67 CON 180±59 **ECM** CNP 235±99 CON 256±100 **Suboccipital** CNP 185±63 CON 196±64	**NPRS (0-10) (on the day)** CNP 4.85±1.58	**NDI** CNP 8.23±2.35	NA

Ge et al. 2014	Cross sectional	n=47 47.6 ± 1.5 14/33	N=17 43.2 ± 2.3 5/12	Pressure algometer (Somedic, Horby, Sweden)	1cm2 30 kPa / sec kPa	**UT** midpoint between C7 and acromion	**ECU** muscle belly. 4cm bellow lateral epicondyle and then 2cm posterior **TA** muscle belly	**UT** CNP 240±112 CON 278±110 **ECU** CNP 258±113 CON 266±78 **TA** CNP 419±174 CON 421±166	**VAS (0-10) (on the day)** CNP 2.3±0.3 **(last 24 hours)** 3.2±1.8	NA	**UT** **Between PPT/VAS** r=-.217
He at al. (2004)	RCT	**Group 1** n=14 49±8 0/14 **Group 2** n=10 45±10 0/10		Algometer (Somedic production AB, Sollentuna, Sweden)	$1cm^2$ $30\ KPa.s^{-1}$ kPa	**UT** midpoint between C7 and acromion **Levator scapula** **Suboccipital** insertion of the suboccipital tendons	NA	**UT** Group 1 192±10 Group 2 268±18 No data from other muscles	**VAS (0-10) (on the day)** Group 1 5.7±0.7 Group 2 4.8±0.9	NA	NA

Heredia-Rizo et al. (2019)	**Part A** Cross sectional **Part B** RCT	n=20 46.8 ± 1.3 0/20	n=20 41.7 ± 2.5 0/20	Eletronic pressure algometer (Somedic AB, Horby, swden)	1cm^2 30 KPa.s^{-1} kPa	**UT** Midpoint between C7 and acromion	**ECU** Muscle belly. 4cm bellow lateral epicondyle and then 2cm posterior.	**UT** CNP 189± 72 CON 209±81 **ECU** CNP 246±98 CON 278±119	**NPRS (last 24h)** CNP 5.30±0.42 CON 0.27±0.12 **NPRS (last week)** CNP 5.30±0.42 CON 0.75±0.19	**NDI** CNP 10.95±1.5 CON 1.15±0.31	**UT between PPT/NPRS** r=-.09 **UT Between PPT/NDI** r=.246

Johnston el al. (2008, 2009)	Cross-sectional	**Group 1** n=33 43±10.5 0/33 **Group 2** n=38 43.8 ± 9.4 0/38 **Group 3** n=14 45.4 ± 10.3 0/14		Digital Algometer (Somedic AB, Farsta, Sweden)	$1cm^2$ 40 $KPa.s^{-1}$ kPa	**UT** Midpoint between C7 and acromion **Levator Scapulae** Muscle belly medial to insertion on superior angle of scapulae **Posterior neck** Semispinalis capitis, just distal to its origin and 2cm from the midline.	**Median nerve trunk** Cubital fossa medial to and immediately adjacent to the tendon of the biceps. **TA** Upper 1/3 of the muscle belly	**Posterior Neck** Group 1 322±160 Group 2 295±122 Group 3 237±72 **Levator Scapulae** Group 1 510±193 Group 2 447±155 Group 3 377±136 **UT** Group 1 389±128 Group 2 329±120 Group 3 303±112 **Median Nerve** Group 1 291±100 Group 2	NA	**NDI** Group 1 4.2 ± 2.6 Group 2 19.5 ± 5.9 Group 3 33.5 ± 3.6	NA

								255±78 Group 3 213±69 **TA** Group 1 499±173 Group 2 426±174 Group 3 393±175			
Kimura et al. (2008)	Uncontrolled trial	n=8 30.8±4.5 0/8		Algesiometer (Igarashi Medical Corp. Tokyo, Japan)	NA 1kgf/cm^2 kgf/cm^2	**UT** Midpoint between C7 and acromion	NA	**UT** **Right** 225.5±68.6 **Left** 186.3±39.2	**VAS (0-10) (on the day)** 6.8 (5.4-7.8)	NA	NA
Nielsen et al. (2010)	**Part A** Cross-sectional **Part B** RCT	n=42 44±8 0/42	n=20 45±9 0/20	Electronic Pressure Algometer (Algometer Type 2; Somedic, Horby, Sweden)	1cm^2 30 KPa.s^{-1} kPa	**UT** Midpoint between C7 and acromion	**TA** Middle distance between lateral condyle of the tibia and the lateral malleolus of the fibula	**UT** CPN 280±82 CON 479±119 **TA** CPN 302±110 CON 464±134	NA	NA	NA

Shahidi et al. (2015)	Prospective Cohort	n=35 29.8±6.8 4/31		Mechanical digital pressure algometer (FPIX 50, Wagner Instruments, Greenwich, CT)	1cm^2 1 kgF/s kg/cm^2	**UT** Muscle belly dominant point	NA	**UT** CNP 382±177	NA	NA	NA
Shahidi & Maluf (2017)	Prospective Cohort	n=17 27.9±7.0 3/14	n=10 26.3 ±3.3 1/9	Mechanical digital pressure algometer (Wagner Instruments, Greenwich, CT)	1cm^2 1 kgF/s kg/cm^2	**UT** Muscle belly dominant point	NA	**UT** CNP 371±177 CON 453±564	**VAS (0-10) (on the day)** CNP 1.62±0.69	**NDI** CNP 3.41±3.48 CON 0.5±0.97	**Between PPT NDI** r=-.141
Valera-Calero et al, (2019)	RCT	**Group 1** n=28 35±8 12/16 **Group 2** n=28 37±10. 10/18 **Group 3** n=27 36±8 10/17		Electronic Pressure Algometer (Wagner FDX-25-Wagner Instruments, Greenwich, CT)	1cm^2 1kg/cm^2/s 1kg/cm^2	**C5/6 zygapophyseal joint**	NA	**Group 1** 187±37 **Group 2** 195±40 **Group 3** 198±44	**VAS (0-10) (on the day)** Group 1 6.39±1.07 Group 2 6.41±1.24 Group 3 6.50±1.62	**NDI (0-50)** Group 1 23.78±10.19 Group 2 23.07±10.25 Group 3 25.24±8.88	NA

Legend: CNP – Chronic neck pain; CON – Asymptomatic controls; ECU – Extensor Carpal Ulnaris; kPA – kilopascal; LT – Lower Trapezius; NA- not attributed; NDI – Neck Disability Index; NPRS – Numerical Pain Rating Scale; PPT – pressure pain threshold; RCT - randomized controlled trials; TA – Tibial Anterior; UT – Upper Trapezius; VAS – Visual Analogue Scale.

e) the lower trapezius point (Andersen C. H. et al., 2014), the sternocleidomastoid (Bragatto et al., 2016) and the C5/6 zygapophyseal joint all measured in one study (Valera-Calero et al. 2019). In relation to the non-neck area, the regions were: a) the tibialis anterior muscle belly point was measured in 6 studies (Johnston et al., 2008, 2009; Nielsen et al., 2010; Andersen L. et al., 2012; Andersen C. H. et al., 2014; Ge et al., 2014; b) the extensor carpi ulnaris in 2 studies (Ge et al., 2014, Heredia-Rizo et al., 2019); c) the median nerve trunk point (cubital fossa medial to and immediately adjacent to the tendon of the biceps) in 2 studies (Johnston et al., 2008, 2009); d) and the middle of the sternum bone in 1 study (Andersen C. H. et al., 2014). All the PPTs points were assessed by palpation.

Pain intensity was assessed in 9 studies (He et al., 2004; Kimura et al., 2008; Andersen L. et al., 2012; Andersen C. H. et al., 2014; Ge et al., 2014; Bragatto et al., 2016; Shahidi & Maluf 2017; Heredia-Rizo et al., 2019; Valera-Calero et al., 2019) by means of the Visual Analog Scale (He et al., 2004; Kimura et al., 2008; Andersen L. et al., 2012; Andersen C. H. et al., 2014; Ge et al., 2014; Shahidi & Maluf 2017; Valera-Calero et al., 2019), and the Numerical Pain Rating Scale (Bragatto et al., 2016; Heredia-Rizo et al ., 2019). Neck Disability Index was measured in 6 studies (Johnston et al., 2008, 2009; Bragatto et al., 2016; Heredia-Rizo et al., 2019; Shahidi & Maluf 2017; Valera-Calero et al., 2019).

4.3.3 Quality Assessment

Table 4.2 presents the results of the methodological quality assessment of the included studies. The discrepancies between reviewers regarding quality assessment outcomes were discussed until consensus was reached. The overall level of agreement between reviewers was 87%, with 0.66 (0.44, 0.84) strength of agreement (Kappa (95%CI)), which is considered to be "substantial" (Cohen 1998). The Downs and Black quality score ranged from 14.2% to 68.7% (mean 55.1± 14.5). The obtained scores interpretation was done according to a previously published procedure (Moita et al., 2017). Briefly, a cut-off point of 50% was established, and based on the overall score quality percentage scores mean and standard deviation (SD 55.1±14.5). In line with that procedure, we determined the intervals by calculating the mean minus 1 SD (40.6) and then mean plus 1 SD (69.6) for the average quality internal, where studies >69.6 were considered of high quality and studies <40.6 were considered to be of low quality. Based on these criteria, the quality assessment of the 13 studies revealed: 9 high average-quality studies (>50% cut-off point) (Johnston et al., 2008, 2009; Andersen L. et al., 2012; Andersen C. H. et al., 2014; Ge et al., 2014; Shahidi et al., 2015; Bragatto et al., 2016;

Shahidi & Maluf 2017; Heredia-Rizo et al., 2019),3 low average-quality study (<50% cut-off point) (He et al., 2004; Nielsen et al., 2010; Valera-Calero et al., 2019), and 1 poor-quality study (Kimura et al. 2008).

Table 4.2 - Included studies quality assessment scores (from modified Downs and Black checklist)

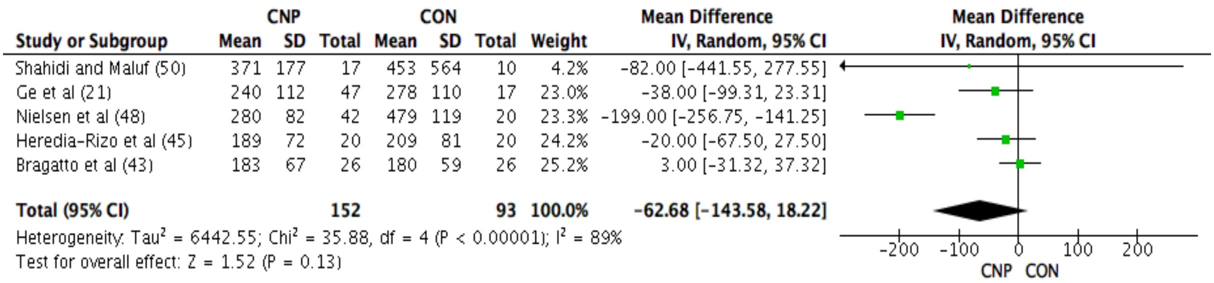
	Items																												
	Reporting										External validity			Internal validity (Bias)							Internal validity (Confounding)						Pwr		
Study	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Score	%
Observational studies n=; max. achievable score 16																													
Bragatto et al[43]	1	1	1	*	1	1	1	*	*	1	1	0	*	*	*	0	*	1	*	1	0	1	*	*	0	*	*	11	68.7
Ge et al[21]	1	1	1	*	1	1	0	*	*	1	0	0	*	*	*	0	*	1	*	1	1	0	*	*	0	*	*	9	56.2
Heredia-Rizo et al[45]	1	1	1	*	1	1	1	*	*	1	0	0	*	*	*	0	*	1	*	1	1	0	*	*	0	*	*	10	62.5
Johnston et al[20]	1	1	1	*	1	1	1	*	*	1	0	0	*	*	*	0	*	1	*	1	0	0	*	*	1	*	*	10	62.5
Johnston et al[46]	1	1	1	*	1	1	1	*	*	1	0	0	*	*	*	0	*	1	*	1	0	0	*	*	1	*	*	10	62.5
Nielsen et al[48]	1	1	1	*	0	1	0	*	*	0	0	0	*	*	*	0	*	1	*	1	0	1	*	*	0	*	*	7	43.7
Shahidi et al[49]	1	1	1	*	1	1	1	*	*	1	0	0	*	*	*	0	*	1	*	1	0	0	*	*	1	*	*	10	62.5
Shahidi & Maluf[50]	1	1	1	*	0	1	0	*	*	1	0	0	*	*	*	0	*	1	*	1	1	1	*	*	0	*	*	9	56.2
Experimental studies with no independent control group n=; max. achievable score 28																													
Kimura et al[47]	1	1	0	1	*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	*	*	0	0	0	0	0	4	14.2
Experimental studies n=; max. achievable score 32																													
Andersen et al[41]	1	1	1	1	1	1	1	0	0	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	1	2	22	68.7
Andersen et al[42]	1	1	1	1	0	1	1	1	1	0	1	1	1	0	0	0	1	1	1	1	1	1	1	0	0	1	1	20	62.5
He et al[44]	1	1	1	1	1	1	1	0	1	1	0	0	1	1	0	0	1	0	0	1	0	0	1	1	0	1	0	16	50.0
Valera-Calero et al[51]	1	1	0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1	0	1	0	0	1	1	0	0	4	15	46.8
Mean % score																													55.1

All questions were scored on the following scale: yes = 1, no = 0, unable to determine = 0; Question 5 is an exception, with scores allocated: yes = 2, partially = 1; no = 0; Question 27 is also an exception with scores ranging from 0 – 5; *Not applicable;.Pwr, power

4.3.4 PPT Values Between CNP and CON

The results of the meta-analysis are shown in figures 4.2a, 4.2b and 4.2c. The PPT measured at the upper trapezius were pooled in 5 studies (Nielsen et al., 2010; Ge et al., 2014; Bragatto et al., 2016; Shahidi & Maluf 2017; Heredia-Rizo et al., 2019) from 152 CNP and 93 CON, without a statistical difference (*p*=0.13). The lower mean value for CNP compared to CON, with a pooled mean difference of -62.68 kPa (95% CI: -143.58, 18.22), revealed a considerable heterogeneity (I^2=89%, Chi^2=35.88, *df*=4, *p*<0.00001) (fig 4.2a).

(a)



(b)

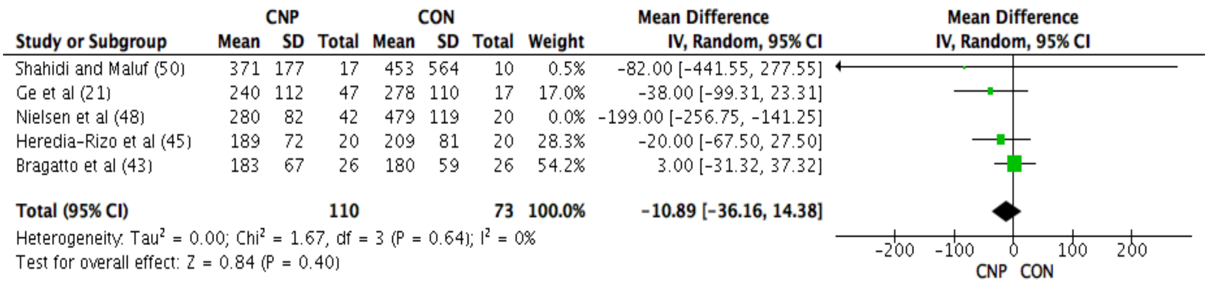


Figure 4.2a – Results of meta-analysis pressure pain threshold (kPa) of upper trapezius muscle in CNP versus CON.

a) all included studies; b) only studies with high quality above average.

The PPTs measured at the extensor carpi ulnaris were pooled in 2 studies (Ge et al. 2014; Heredia-Rizo et al., 2019) from 67 CNP and 37 CON, without a statistical difference *p*=0.42. The lower mean value for CNP compared to CON, with a pooled mean difference of -16.31 kPa (95% CI: -56.07, 23.45), revealed a not important heterogeneity (I^2=0%, Chi^2=0.32, *df*=1, *p*=0.57) (fig 4.2b).

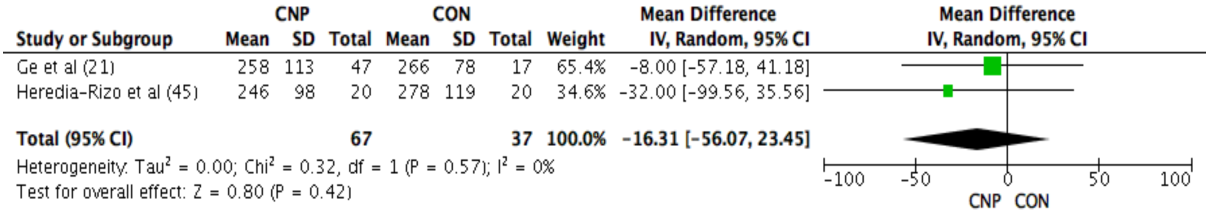


Figure 4.2b - Results of meta-analysis pressure pain threshold (kPa) of extensor carpi ulnaris in CNP versus CON.

The PPTs measured at the tibialis anterior were pooled in 2 studies (Nielsen et al., 2010; Ge et al., 2014) from 89 CNP and 37 CON, without a statistical difference p=0.29. The lower mean value for CNP compared to CON, with a pooled mean difference -85.37 kPa (95% CI: -242.03; 71.29), revealed a considerable heterogeneity (I^2=87%, Chi^2=7.42, df=1, p=0.006) (fig 4.2c)

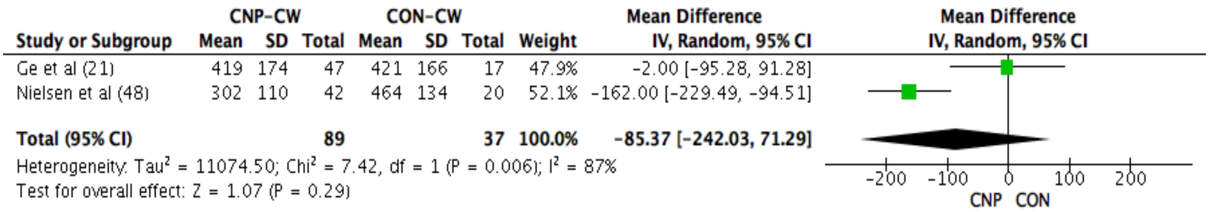


Figure 4.2c - Results of meta-analysis pressure pain threshold (kPa) of tibialis anterior in CNP versus CON

4.3.5 PPT Reference Values in Office Workers with CNP

The PPTs measured at the upper trapezius were pooled in 11 studies (He et al., 2004; Johnston et al., 2008; Kimura et al., 2008; Nielsen et al., 2010; Andersen L. et al., 2012; Andersen C. H. et al., 2014; Ge et al., 2014; Shahidi et al., 2015; Bragatto et al., 2016; Shahidi & Maluf 2017; Heredia-Rizo et al., 2019), from 549 office workers, and found a statistical difference (p<0.001), with a mean value of 263.03 kPa (95%CI: 236.35, 289.70), and considerable heterogeneity (I^2=94%, Chi^2=160.2, *df*=10, p<0.001) (Figure 4.3a).

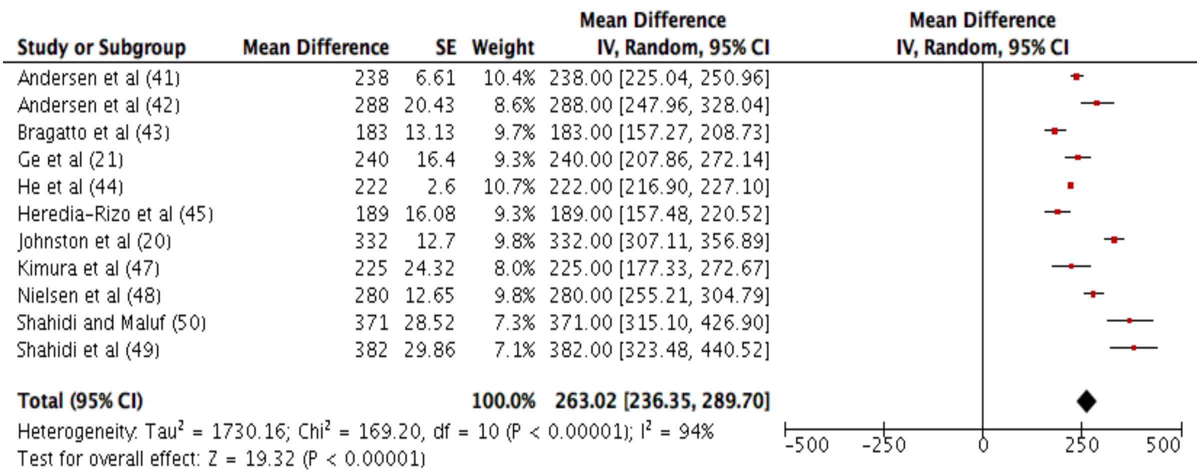


Figure 4.3a - Results of meta-analysis pressure pain threshold (kPa) for upper trapezius reference values in CNP.

The PPTs measured at the extensor carpi ulnaris were pooled in 2 studies (Ge et al., 2014; Heredia-Rizo et al., 2019) from 67 office workers, and found a statistical difference (p<0.001), with a mean value of 253.66 kPa (95%CI: 227.82, 279.51), and insignificant heterogeneity (I^2=0%, Chi^2=0.19, *df*=1, p=.66) (Figure 4.3b).

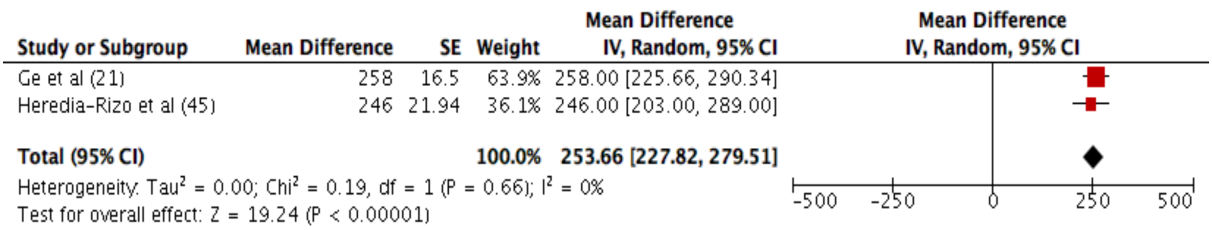


Figure 4.3b - Results of meta-analysis pressure pain threshold (kPa) for extensor carpi ulnaris reference values in CNP**.**

The PPTs measured at the tibialis anterior were pooled in 5 studies (Johnston et al., 2008; Nielsen et al., 2010; Andersen L. et al., 2012; Andersen C. H. et al., 2014; Ge et al., 2014), featuring 419 office workers, and found a statistical difference (p<0.001), with a mean value of 365.89 kPa (95%CI: 316.66, 415.12), and considerable heterogeneity (I^2=92%, Chi^2=50.26, *df*=4, p<.00001) (Figure 4.3c). Subgroup analysis revealed that I^2 values did not change in the upper trapezius or the tibialis anterior PPTs when taking into account studies with Downs and Black score below average and poor quality.

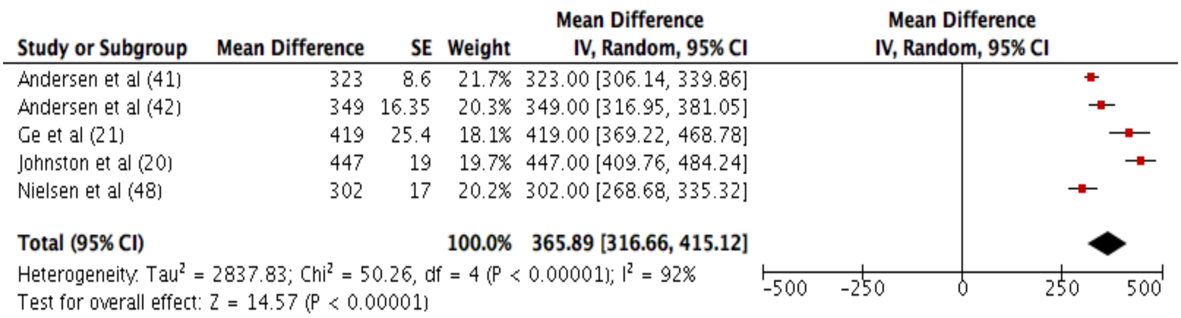


Figure 4.3c - Results of meta-analysis pressure pain threshold (kPa) for tibial anterior reference values in CNP.

4.3.6 Correlations Between Upper Trapezius PPT and Pain Intensity in CNP

Figure 4.4 illustrates the non significant correlation analysis between the upper trapezius PPT and pain intensity. The weighted mean r_z value was -0.18 (p=0.15) with a not important heterogeneity (I^2=0%, Chi^2=0.21, df=1, p=0.65). The back transformed r-value of -.178 indicated a non-significant negative small-sized correlation.

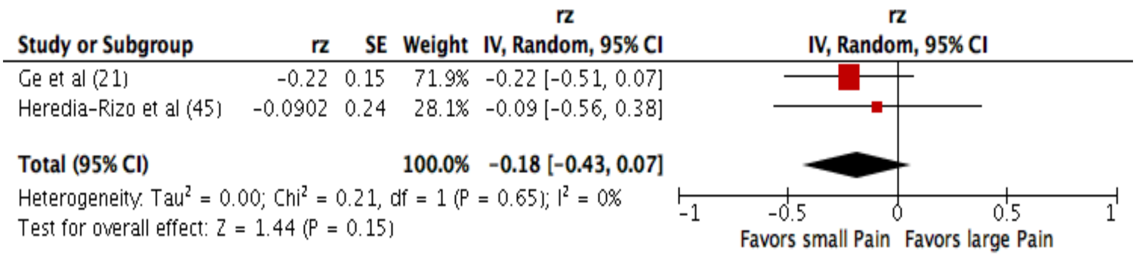


Figure 4.4 - Pearson's r-values (z-transformed) for correlation between pressure pain threshold (kPa) and pain intensity in CNP.

4.3.7 Correlations Between Upper Trapezius PPT and Disability in CNP

Figure 4.5 reports the non significant correlation analysis between the upper trapezius PPT and disability measured by Neck Disability Index. The weighted mean r_z value was 0.07 (p=0.73) with a not important heterogeneity (I^2=19%, Chi^2=1.23, df=1, p=0.27). The back transformed r-value of 0.699 indicated a small-sized correlation.

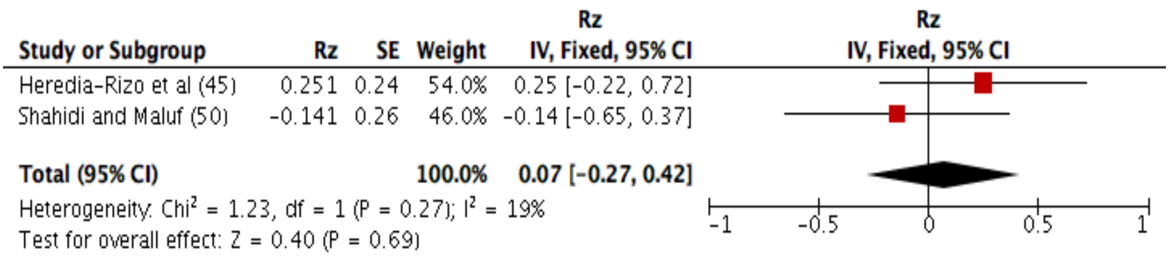


Figure 4.5- Pearson's r-values (z-transformed) for correlation between pressure pain threshold (kPa) and neck disability index in CNP.

4.4 Discussion

This systematic review and meta-analysis showed non significant changes in PPTs assessed at the upper trapezius, the extensor carpi ulnaris and the tibialis anterior comparing CNP and CON. The PPTs results from the extensor carpi ulnaris and the tibialis anterior were drawn based on only two studies with small sample size. The present review provides PPTs reference values for the upper trapezius and the tibialis anterior for office workers with chronic neck pain. Finally, no significant correlations were found between PPTs, clinical pain or disability in patients with CNP, also from two studies with small sample size.

4.4.1 PPT Between CNP and CON

All the analysis revealed decreased PPTs values in CNP when compared to CON, without a statistical significance and with a small difference in the extensor carpi ulnaris and the upper trapezius when this analysis was conducted with average quality studies. Also, the sample size from all analyses were not representative of an office worker population. Nevertheless, these results were quite similar with the findings of other systematic reviews comparing PPTs between symptomatic and asymptomatic subjects in (1) migraine (Andersen S. et al., 2015; Castien et al., 2018; Nahman-Averbuch et al., 2018); (2) tension-type headache (Andersen S. et al., 2015; Castien et al., 2018); (3) cervicogenic headache (Castien et al., 2018); (4) chronic whiplash-associated disorder (Stone et al., 2013); (5) chronic non-specific neck pain (den Bandt et al., 2019).

Only the reviews from patients with migraine, tension-type headache and cervicogenic headache (Castien et al., 2018; Nahman-Averbuch et al., 2018), demonstrate localized hyperalgesia (head and neck PPTs points) and not widespread hyperalgesia. In a chronic condition, lower PPTs in local and distal points may reflect widespread hyperalgesia (Arendt-Nielsen et al., 2011, 2018). Although the current analysis observed lower PPTs values remote from the neck region, particularly in the tibialis anterior with a difference of 85 kPA, are based on one low quality study with considerable heterogeneity and a small sample size. Therefore, future studies should be aimed at investigating this observation.

4.4.2 PPT Reference Values for CNP

The meta-analysis proposed PPTs reference values for the upper trapezius and the tibialis anterior, 263 kPa, and 366 kPa, respectively, in office workers with CNP. From the included studies, the upper trapezius PPT value ranged from 183 kPa to 371 kPa meaning there is a substantial variability within CNP. PPTs measured by algometry is a reliable tool in different neck conditions, with a good to almost perfect intra-rater reliability in chronic neck pain (Ylinen et al., 2007), myofascial pain (Park et al., 2011); acute neck pain (Walton et al., 2011), and in the cervical region in patients with dizziness (Knapstad et al. 2018). Therefore, this variability has been attributed to gender, different measurement positions, repeated measurements, between subjects and peak pressures being more heterogeneous in bone points, which is not the case in the PPTs points included in our review (Melia et al. 2019). In addition, it should be noted that different algometers are used for assessing PPT and this could influence the results. Currently, no studies have investigated the differences in the different algometers. A secondary analysis in the upper trapezius PPTs demonstrated higher values in the studies that used a mechanical pressure algometer compared with the studies that used an electronic pressure algometer (Appendix 4). This needs to be interpreted with precaution because of considerable heterogeneity and differences in the sample size.

From a clinical perspective, it is crucial that guidelines describing a common methodologic approach, and reference PPTs values. Normative cut off points with reference values corresponding to the 10^{th} and 25^{th} percentile from the mean in free-pain populations has been proposed as a lower PPT limit value to be considered as hypersensitive (Neziri et al., 2011; Waller et al. 2016). Considering that the PPTs in the upper trapezius and the tibialis anterior in CNP were composed of 88% and 84% females office workers, respectively, and men have higher PPTs values (Melia et al. 2019) in free-pain populations (Neziri et al., 2011; Andersen S. et al., 2015; Waller et al. 2016), and in chronic pain populations (Andersen S. et al., 2015), it is possible to make some conclusions based on the mentioned studies. Neziri et al., (2011) proposed the normal value for PPTs was 212 kPa and considered hypersensitivity values below 153 kPa for females when assessing the scapula (30 mm below upper trapezius point) (Ge at al. 2014). Waller et al. (2016) proposed similar results, with normal PPTs at 245 kPa when assessing the upper trapezius, and hypersensitivity values below 155 kPa in females; and normal PPTs at 394 kPa when assessing the tibialis anterior and hypersensitive values being below 246 kPa in females. The values pooled from the CNP groups in the current review were very similar for females, and so, the values below 155 kPa and 245 kPa in the upper trapezius and the tibialis anterior, can be proposed as hypersensitive values for office workers with chronic neck pain.

In this review, due to the few studies and small sample size with CON, it was not possible to pooled PPTs values to compare with free-pain populations. Further studies are necessary to investigate PPTs in healthy OW.

4.4.3 Correlations Between PPT and Pain Intensity and Disability

This meta-analysis found a small association between PPT measured in the upper trapezius and pain intensity, from only two studies derived from a small sample size (67 office workers) (Ge et al., 2014; Heredia-Rizo et al., 2019). No observed association has been described in the literature between PPTs values and pain intensity in acute neck pain (Walton et al., 2011), in chronic headache (Castien et al. 2018), adolescents with chronic pain (Tham et al., 2016) and in temporomandibular disorders (Sanches et al., 2015)

There was a smaller association in Neck Disability Index from two studies with 37 office workers with chronic neck pain Shahidi & Maluf 2017; Heredia-Rizo et al., 2019). A few studies have reported correlations between PPTs in the upper trapezius and disability in patients with neck pain. Walton et al. (2014) reported a weak correlation, Beltran-Alacreu et al. (2018) reported a moderate negative correlation and no significant correlation in patients with chronic neck pain (La Touce et al. 2010).

4.4.4 Limitations

Several limitations were found: a) lack of data in the included studies have limited the robustness of the meta-analysis; b) lack of reporting pain duration making it difficult to conclude if the condition was chronic accordingly with the recent ICD-11 classification (Smith et al., 2019); c) to conduct the meta-analysis required at least two studies with the same PPT point and one of the included studied (Valera-Calero et al., 2019) measured in one point that was not repeated by the other studies; d) two of the excluded studies were not possible to conclude the PPTs assessment points; e) the findings from this review may not be generalizable beyond female gender due to the limited inclusion of male participants in the studies reviewed; f) and finally, across all studies, the PPTs points were assessed through palpation raising questions regarding standardization (Melia et al., 2019).

4.4.5 Conclusion

This meta-analysis found that all the pressure pain threshold measurements were not significantly reduced in office workers with chronic neck pain compared with healthy workers. These assumptions were based on a small sample of existing studies, and therefore further studies are necessary to quantify the differences in pressure pain thresholds. Therefore, these conclusions should be interpreted with caution.

This review proposed hypersensitivity reference values for the upper trapezius and the tibialis anterior for localized and extra-segmental assessment of pressure pain thresholds in chronic neck pain.

4.5 Reference List

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5

Neck pain prevalence and associated occupational factors in Portuguese office workers[2]

[2] Nunes, A., Espanha, M., Teles, J., Carnide, F., Petersen, K., Arendt-Nielsen, L., Carnide, F (2020). Neck pain prevalence and associated occupational factors in Portuguese office workers. International Journal of Industrial Ergonomics (accepted to be published).

5.1 Introduction

In Portugal, the use of computer for office workers increased from 27.4% to 66.8% from 2002 to 2017 (INE 2019a). More than 84% of the population between 16-44 years of age use computer (INE 2019a). In 2019, the average computer use was 99.2% in all economic sectors (INE 2019b) in companies with more than ten workers. In professions that use a computer, like office workers, the generalize pain involving neck/shoulder ranged from 20% to 60%, a problem verified worldwide (Côte et al., 2008; Sarquis et al., 2016). In Portugal, the prevalence of neck pain has been reported to be approx.20% (Cunha-Miranda et al., 2010). Lately, telework has been increasing, especially due to the pandemic situation, and, have been calling attention to the adverse outcomes of the work conditions, namely the musculoskeletal impairments in the neck and shoulder segments (Tavares 2017). In the Global Burden of Disease reports (Vos et al., 2016) neck pain rank among the top 4 global burden for many years but as compared to the other top-ranking diseases few pharmacological and non-pharmacological randomized controlled trials have been conducted to explore the best management options for this possible disabling and quality of life reducing condition.

In office workers with neck pain, the average self-reported productivity loss had been reported between 20% and 43% (Hagberg et al., 2002; van de Heuvel et al., 2007; Madeleine et al., 2013). This loss of productivity increases with upper limb pain symptoms (van de Heuvel et al., 2007). Also, the risk of work sickness absence increased almost three times in subjects with neck pain (Matsudaira et al., 2011).

Several systematic reviews and meta-analysis call for identification of risk factors for neck pain in office workers (IJmker et al., 2007; Larsson et al., 2007; Waersted et al., 2010; Andersen et al., 2011; Paksaichol et al., 2012; Jun et al., 2017; Coenen et al. 2019). Accumulating evidence suggests that female are in higher risk and that previous history of neck pain predicts a onset of neck pain (Paksaichol et al., 2012). Studies suggest that satisfaction with the workplace environment, closed keyboard position, low task variation, self-perceived muscle tension (Jun et al. 2017), and computer use *per si* (Andersen et al., 2011; Coenen et al., 2019) predict onset of neck pain.

Ergonomics interventions can reduce neck pain in office workers (Aas et al., 2011; Hoe et al., 2012; Hoe et al., 2018). Still, perhaps the most important, in cases of chronic neck pain, is to reduce the physical strain in the musculoskeletal system, for other types of interventions to become more effective. Also, the advances in technology in the past few years, resulted in substantial work changes, like the increase use of laptop and desktop and/or multiple screens with different sizes at the same time (Woo et al., 2015). There is still necessary to quantify the association of the use of new technologies, like the use of a laptop, with neck pain in office workers (Coenen et al., 2019).

Therefore, the aims of this study were 1) to assess the prevalence of neck pain and to identify associated occupational factors in a cohort of office workers and 2) to assess the prevalence of body areas with pain in office workers with and without neck pain.

5.2 Methods

5.2.1 Subjects

From May 2017 to April 2019, 2595 office workers from the Lisbon University, Algarve University, Albufeira City Council, and a private Portuguese supermarket company (central services) were invited to participate in the study. The work characteristics and environment of these different work setting are mainly characterized by 8 hours of administrative tasks (finances, central shopping centers, occupational safety and health management), that include the use of computer, mouse and keyboard, as well as document manipulation, at least 3/4 of the work shift. The work pace is free. The participation consisted of filling-out a web-based questionnaire. The eligible criteria were: adult office worker from 18-65 years of age; to have seniority higher than 1 year in the same job position; to have a rate of least 3/4 of the working hours with a computer (Johnston et al., 2008; Sjörs et al., 2011; Andersen et al., 2014); understand the Portuguese Language.

This research was conducted in accordance with the Declaration of Helsinki and was approved by the Ethic Council (CEFMH) at the Faculty of Human Kinetics – Lisbon University (Approval Number:23/2017). All participants gave written informed consent.

5.2.2 Self-reported measures

A structured web-based questionnaire was designed and supported on previous studies (Kiss et al., 2012; Madeleine et al., 2013; Garza et al., 2014). It included questions related to demographics and anthropometric parameters, work-related variables, workstation setup, and musculoskeletal complaints.

Regarding the demographic and anthropometric parameters, include age, gender, height and weight to calculate body mass index.

The computer work-related variables were: the number of working years at a computer was asked in three categories: “10 years or less”, “between 11 and 20 years”, and “more than

20 years". The number of working hours per week was asked in three categories: "less than 36 hours", "between 36 and 40 hours", "more than 40 hours". The number of working hours on a computer per day was asked in five categories: "4 hours or less", "5 hours, "6 hours", "7 hours", "8 hours or more". The number of hours working on a computer without a break in three categories "1 hour", "2 hours", "3 hours or more".

The workstation layout included the type of computer for office work, categorized into three categories: "laptop", "desktop" or "both". The use of documents was asked in "no" and "yes", and if "yes" categorized in: "side of the keyboard", or "between screen and keyboard". Screen position was evaluated in relation to eye level into three categories: "upper border screen eye level", "upper border screen below eye level" and "upper border screen above eye level. Screen localization was evaluated in relation to working position into three categories: "in front", "right side" or "left side". Elbow position was asked relative to keyboard during keyboard working into three categories: "at same level", "below" and "above". Forearm support during keyboard work into three categories: "no forearm support", "forearm supported for less than 2/3 on the work table", "forearm supported more than 2/3 on the work table". The use of mouse during work dichotomized in two categories: "less than 50% of working time on computer" and "more than 50% of working time on computer". Mouse localization on the work table into three categories: "close to the table edge", "beside keyboard", "fairway from the keyboard".

Finally, the musculoskeletal pain complaints were evaluated by the Portuguese version of the Standardized Nordic Musculoskeletal Questionnaire (Mesquita et al., 2010).

5.2.3 Statistical analysis

Descriptive statistics were calculated for age, gender, BMI, working time per week, computer work hours per day, computer work per year, the average of musculoskeletal pain per segment, number of body segments with pain and neck pain causes.

The prevalence of several musculoskeletal pain conditions was determined using point estimates and 95% Clopper-Pearson confidence intervals.

Simple logistic regression analysis was used to calculate the odds ratio and their 95% confidence intervals for the presence of neck pain for each occupational factor. A multiple logistic regression analysis, using a stepwise method for variable selection, was done considering the variables of the simple logistic regression with p-value <0.20 as candidate variables (Hosmer et al., 2013). In each model, the polychotomous variables were transformed into "dummy" variables for the calculation of Odds Ratio, concerning the reference category of each of these variables.

Some determinant factors of the models were reorganized in new categories using the following cut-offs: age in "between 25 and 39 years", "between 40 and 49 years", "between 50 and 65 years"; the number of working hours on a computer per day was dichotomized "6 hours or less" or "more than 6 hours"; screen position was dichotomized in "eye level" or "no eye level"; screen localization was dichotomized in "center" or "not center"; elbow position was asked relative to the keyboard during keyboard working was dichotomized in "same level" or "not level"; and mouse localization on the work table was dichotomized in "keyboard side" or "no keyboard side". The main outcome, neck pain, was dichotomized according to the cut-off of 3 in the pain intensity scale used in the Nordic Questionnaire (Sihawong et al., 2016). $P<0.05$ was considered significant.

The statistical analysis was conducted using SPSS 25.0 software (SPSS Inc., Chicago, IL, USA).

5.3 Results

5.3.1 Sample caracterization

From the 2595 office workers population, 601 completed the questionnaires, which corresponded to an answer rate of 23.1%. From those, 436 were female (72.5%), and 165 were male (27.5%). The mean age and working years on a computer of the sample were 44.2 years (SD 9.1) and 18.7 years (SD 8.2), respectively. Table 5.1 reported office workers individual characteristics.

Table 5.1 – Characteristics of office workers (n=601)

Individual Characteristics	***N (%)***	***M* ± SD**
Age (years)		44.2 ± 9.1
Gender (female/male)	436 (72.5) / 165 (27.5)	
BMI (kg/m^2)		24.8 ± 4.0
Working time (h/wk)		39.3 ± 6.7
Computer work (h/day)		6.5 ± 1.5
Computer work (years)		18.7 ± 8.2
Office workers with neck pain (yes / no)	337 (56.1) / 264 (43.9)	

Abbreviations : BMI – Body Mass Index

5.3.2 Prevalence of neck pain and body areas with pain

In office workers reporting pain the prevalence of neck pain was 56.1% (95 CI 52.0-60.1). The prevalence of pain in the other body regions were for shoulder 40.1% (95 CI 36.2-44.1), for low back 38.8% (95 CI 34.9-42.8), for dorsal 27.6% (95 CI 24.1-31.41), for wrist/hand 24.0 % (95 CI 20.6-27.6), for knee 11.6% (95 CI 9.2-14.5), for ankle 7.8% (95 CI 5.8-10.3), and finally for hip 5.0% (95 CI 3.4-7.0).

Office workers with pain (n=468) self-reported less than three body segments represented 71.3% (n=334), meaning that 28.7% (n=134) reported pain in more than three body segments. In office workers with neck pain (n=337), self-reported less than three body segments represented 64.4% (n=217), meaning that 35.6% (n=120) reported pain in more than three body segments. Only 37 office workers reported neck pain without pain in other body area (table 5.2).

Table 5.2 – Number of body areas with pain and those with neck pain

Number of Body Areas	Office workers with pain (n=468)			Office workers with neck pain (n=337)		
	N	%	95% CI	N	%	95% CI
1	97	20.7	[17.1, 24.7]	37	11.0	[7.6, 15.3]
2	133	28.4	[24.4, 32.7]	96	28.5	[19.6, 30.0]
3	104	22.2	[18.5, 26.3]	84	24.9	[20.3, 30.8]
4	64	13.7	[10.7, 17.1]	54	16.0	[10.4, 18.9.1]
5	35	7.5	[5.3, 10.2]	32	9.5	[6.7 60.1]
6	19	4.0	[2.5, 6.3]	18	5.3	[3.3 9.1]
7	10	2.1	[1.0, 3.9]	10	3.0	[1.5, 6.0]
8 and 9	6	1.3	[0.5, 2.8]	6	1.8	[0.6, 4.1]

5.3.3 Associations between neck pain, age, and computer work-related factors

In a simple logistic regression analyses, "age between 50-65 years" [OR: 1.96 (1.29-2.96) *P*=0.001], and "working more than three hours without a break" [OR: 1.90 (1.10-3.28) *P*=0.02] were the risk factors significantly associated with the development of neck pain. The number of working hours per week between "36-40 hours" [OR: 0.52 (0.35-

0.78) *P*=0.001] and "more than 40 hours" [OR: 0.47 (0.32-0.71) *P*<0.001] were a significant protective factor for neck pain (table 5.3).

Table 5.3 - Prevalence of neck pain in the past 12 months and associations with age and computer work-related factors, evaluated using simple logistic regression analyses

Variable	Total number of office workers	Number and percentage of OW with chronic neck pain, reporting ≥ 3 in VAS (0-10)		*P*	OR (95% CI)
	n	n	%		
Age (years)					
25-39	194	78	40.2		1
40-49	231	103	44.6	0.36	1.20 (0.81-1.76)
50-65	176	100	56.8	**0.001**	**1.96 (1.29-2.96)**
Number of working hours per week					
<36	281	157	55.9		1
36-40	171	68	39.8	**0.001**	**0.52 (0.35-0.78)**
>40	149	56	37.6	**<0.001**	**0.47 (0.32-0.71)**
Number of working hours on a computer per day					
≤6	281	140	49.8		1
>6	320	141	44.1	0.11	0.77 (0.56-1.06)
Number of years working at a computer					
<10	116	50	43.1		1
11-20	242	111	45.8	0.62	1.12 (0.72-1.47)
>20	243	120	49.4	0.27	1.29 (0.82-2.01)
Number of working hours on a computer without a break					
1	67	23	34.3		1
2	175	79	45.1	0.13	1.57 (0.88-2.83)
>3	359	179	49.9	**0.02**	**1.90 (1.10-3.28)**

Abbreviations: OR: Odds Ratio; CI – Confidence Interval.

In the multiple logistic regression analyses, age between "50-65 years" [OR: 1.92 (1.26-2.91) *P*=0.002], "working two hours without a break" [OR: 1.82 (1.00-3.31) *P*=0.05], and "working more than three hours without a break" [OR: 2.41 (1.35-4.10) *P*=0.003] were the risk factors significantly associated with the development of neck pain (table 5.4).

Table 5.4 – Multiple logistic regression model for the presence of neck pain in office workers for age and computer work-related factors.

Variable	***P***	**OR (95% CI)**
Age (years)		
25-39		1
40-49	0.56	1.12 (0.76-1-66)
50-65	**0.002**	**1.92 (1.26-2.91)**
Number of working hours on a computer per day		
≤6		1
>6	**0.016**	**0.65 (0.46-0.92)**
Number of working hours on a computer without a break		
1		1
2	**0.05**	**1.82 (1.00-3.31)**
>3	**0.003**	**2.41 (1.35-4.30)**

Abbreviations: OR: Odds Ratio; CI – Confidence Interval.

5.3.4 Associations of neck pain with workstations setup

In a simple logistic regression analyses, "screen localization not centered" [OR: 2.12 (1.09-4.16) *P*=0.03] was the risk factor significantly associated with the development of neck pain. Working with a laptop [OR: 0.51 (0.32-0.80) *P*=0.04] was a significant protective factor associated with neck pain (table 5.5).

Table 5.5 - Prevalence of neck pain in the past 12 months and associations with workstations layout, evaluated using simple logistic regression analyses.

Variable	**Total number of office workers**	**Number and percentage of OW with chronic neck pain, reporting ≥ 3 in VAS (0-10)**		***P***	**OR (95% CI)**
	n	**n**	**%**		
Computer Type					
Desktop PC	364	183	50.3		1
Laptop	103	35	34.0	**0.04**	**0.51 (0.32-0.80)***
Mist	134	63	47.0	0.52	0.88 (0.59-1.30)
Usual position of documents					
keyboard/screen	144	67	46.5		1
Side keyboard	388	185	47.7	0.81	1.05 (0.71-1.54)
Screen					
Screen Localization					
Center	454	216	47.6		1
Not center	41	27	65.8	**0.03**	**2.12 (1.09-4.16)***
	n	**n**	**%**		
Height upper border screen					
Eye level	365	170	46.6		1
No eye level	130	73	56.1	0.06	1.47 (0.98-2.20)
Keyboard					
Elbow position relative to keyboard					
Same Level	398	182	45.7		1
Not level	203	99	48.7	0.48	1.13 (0.80-1.58)
Forearm support					
More 2/3 forearm	303	136	44.9		1
Less 2/3 forearm	139	70	50.3	0.28	1.25 (0.83-1.86)
No support	159	75	47.2	0.64	1.10 (0.75-1.61)
Mouse					
Use of computer mouse during worktime					
<50%	73	27	37.0		1
>50%	516	252	48.8	0.06	1.63 (0.98-2.70)
Mouse localization during work					
Keyboard side	425	193	45.4		1
No keyboard side	170	87	51.2	0.21	0.79 (0.56-1.13)

Abbreviations: OR: Odds Ratio; CI – Confidence Interval.

Multiple logistic regression analysis was performed on the risk factors variables with a *p*<0.20 extracted from the previous step to determine the association of each variable with neck pain. "Screen localization not centered" [OR: 2.01 (1.01-4.00) *P*=0.045] and the "use of computer mouse during worktime more than 50%" [OR: 2.05 (1.14-3.71) *P*=0.017] were the risk factors significantly associated with the development of neck pain (table 5.6).

Table 5.6 – Multiple logistic regression model for the presence of neck pain in office workers for workstation layout.

Variable	***P***	**OR (95% CI)**
Screen Localization		
Center		1
Not center	**0.045**	**2.01 (1.01-4.00)**
Height upper border screen		
Eye level		1
No eye level	0.058	1.49 (0.99-2.24)
Use of computer mouse during worktime		
<50%		1
>50%	**0.017**	**2.05 (1.14-3.71)**

Abbreviations: OR: Odds Ratio; CI – Confidence Interval.

5.4 Discussion

This study reported the prevalence of neck pain and to identified associated occupational factors in a cohort of office workers. The study found a high prevalence of neck pain followed by pain in the shoulder, low back, dorsal and wrist/hand segments in office workers. Moreover, there was a high number of office workers with pain in more than three body segments. For neck pain, the variables age and computer work-related factors for neck pain, the "age between 50-65 years" and "the number of working hours on a computer without a break" were the most relevant risk factors. For the workstation layout variables for neck pain, "screen localization not centered" and "the use of computer mouse more than 50% during worktime", were the most relevant risk factors.

5.4.1 Prevalence of neck pain and body areas with pain

The high prevalence of neck pain in office workers in our study was quite similar with previous studies (Jensen et al., 2003; Sillanpää et al., 2003; Wahlström et al., 2004; Juul-

Kristensen & Jensen 2005; Cagnie et al., 2007; Janwantanakul et al., 2008; Ranasinghe et al., 2011; Kiss et al., 2012; Cho et al., 2012; Oha et al., 2014; Piranveyseh et al., 2016; Celik et al., 2017; Chen et al., 2018; Shariat et al., 2018). Compared with a previous Portuguese study, the prevalence was considerably lower, about one third (19.2%) (Cunha-Miranda et al., 2010). However, our results in office workers with pain in other body regions were similar with previous studies, regarding low back pain (Juul-Kristensen & Jensen 2005; Janwantanakul et al., 2008; Piranveyseh et al., 2016; Harcombe et al., 2010; Celik et al., 2017; Shariat et al., 2018), shoulder pain (Sillanpää et al., 2003; Eltayeb et al., 2009; Harcombe et al., 2010; Ranasinghe et al., 2011; Cho et al., 2012; Piranveyseh et al., 2016; Celik et al., 2017; Shariat et al., 2018), dorsal (Janwantanakul et al., 2008; Cho et al., 2012; Celik et al., 2017), and wrist/hand pain (Sillanpää et al., 2003; Janwantanakul et al., 2008; Eltayeb et al., 2009; Harcombe et al., 2010; Ranasinghe et al., 2011; Piranveyseh et al., 2016; Celik et al., 2017).

Another significant report from our study was the number of body segments with pain. The primary *International Classification of Diseases, 11^{th} Revision (ICD-11)* (World Health Organization, 2020), classified chronic widespread pain has a diffuse pain in at least in 4 of 5 body regions with associated emotional distress. The chronic widespread pain average in the general population ranged from 10 to 15% (Mansfield et al., 2016; Andrews et al., 2018). In the current study, there was no information considering emotional distress and was used a different number of body regions, but our numbers should raise concern in this population.

Unfortunately, this is not very often reported in study designs similar to our study. Nevertheless, in the study from Tornqvist et al. (2009) the co-morbidity in office workers with neck, shoulder and arm/hand symptoms plus symptoms in one more region ranged from 27 to 53% of the cases per segment. Regarding productivity loss, it increased from 10 to 36% when office workers had together neck/shoulder and arm/hand symptoms (van den Heuvel et al., 2007).

5.4.2 Associations between independent variables and neck pain

In the present study, office workers "between 50-65 years of age" and "working more than 2 hours on a computer without a break" increased almost two times the risk for neck pain. From the literature, there is conflicting evidence from these two risk factors. Several studies did not find an association between age and neck pain (Jensen et al., 2003; Jull-Kristensen & Jensen 2005; Ranasinghe et al., 2011; Paksaichol et al., 2012; Celik et al. 2018). In the study from Gerr et al. (2002) was reported a slight increase in the risk ratio of 0.3 points from the age

30-39 to more than 40 years. In the opposite direction, Cagnie et al. (2007) found a U-shaped association where the pain increased until the age of 50 years and then it started to decrease.

Concerning the variable "working on a computer without a break" associated with neck pain in office workers, some studies reported a similar result with our research (Cagnie et al., 2007; Kiss et al., 2007; Celik et al., 2018). However, there was no association in other studies (Hagberg et al., 2007; Ranasinghe et al., 2011). In a meta-analysis with longitudinal studies, there was no significant association with neck pain (Jun et al., 2017). Nevertheless, is recommended a break of 5 to 15 minutes for every hour of work on a computer (Woo et al., 2015).

In the current study, in the workstation layout variables, the "screen localization not centered" and the "use of computer mouse more than 50% during the worktime", increased two times the risk for neck pain. The research was more in favor of no association of the risk factor related to "duration of the mouse work" with neck pain (Sillanpää et al., 2003; Brandt et al., 2004; Hagberg et al., 2007). A systematic review and meta-analysis from prospective studies conclude there was no significant risk ratio for the "duration of mouse use" for the development of neck pain (Jun et al., 2017). To our knowledge, only the study from Kiss et al. (2012) demonstrated an identical result with our study.

Concerning the "screen localization" the majority of the studies evaluate the screen height adjusted to eye level and not if the screen was placed in front or sideways in relation to the office worker. The studies from Kiss et al. (2012) and Celik et al. (2018) did not found a significant association with neck pain if the computer screen was not in front of the worker. Nevertheless, the standards and guidelines for computer work and workstation recommended the computer screen to be placed in front of the worker. Moreover, the frequency of neck pain was higher in the mentioned factors, reinforcing the need for ergonomic adjustment during computer work (Woo et al., 2015).

Finally, in the past few years, there was an increased use of laptop and multiple screens at work (Woo et al., 2015). In the present study, the use of a laptop in the simple logistic regression analyses showed a statistically significant protective factor for neck pain. To our knowledge, this was the first observational study in office workers that differentiate between a desktop computer, laptop and use both simultaneously, as an associated factor for neck pain. The difference in sample sizes in our study between laptop and desk computer can explain our result. A further explanation is the age of the office workers using laptop was statistical lower compared with the users of desktop (p=0.045) (Appendix 1). Mainly when is reported that subjects with chronic neck pain, the use of laptop compared with desktop computer increases neck and upper trunk flexion, bilateral shoulder elevation, which can contribute to neck pain (Lee et al., 2020). Previous studies associated "irregular head posture" (Cagnie et al., 2007; Eltayed et al., 2009), and "awkward body posture" (Ranasinghe et al., 2011) as risk factors for neck pain in office workers. Further studies are necessary to associate laptop and other technology devices as risk factors for musculoskeletal disorders.

5.4.3 Implications for practice

The high prevalence of neck pain and the presence of a significant number of body segments with pain in office workers require a detailed pain mechanism assessment. This can be a basis for treatment and interventions to reduce the prevalence of pain in this population. Decision-makers and employers need to be included in this process, as working time and workstation setup variables were risk factor associated with the development of neck pain. The study in conjunction with the many other neck pain studies calls for concerted actions to explore optimal and efficient management regimes in randomized, controlled studies.

5.4.4 Study Limitations

The present study has some limitations that should be considered. This study was inside in a research project designed to study neck pain. Thus, office workers with neck pain may lead to an increasing number in replying the online questionnaire instead of office workers without neck pain. The reporting of pain or discomfort may be biased, due to the fact, that office workers had to report the segments of pain with more than thirty days in the last twelve months (Ranasinghe et al., 2011). This observational study with a cross-sectional design consisted of an online questionnaire that relies on self-reported measures. The sample size was not analyzed regarding gender where there is strong evidence from prospective cohort studies that gender female was a risk factor for neck pain in office workers (Paksaichol et al., 2012). The absence of the possibility of in-depth characterization of working conditions by observational methods, such as the "Rapid Upper Limbs Assessment-RULA" (McAtamney and Corlett 1993) or "Rapid Office Strain Assessment-ROSA" (Sonne et al. 2012), could be an important issue to highlight. However, considering the high sample size, it was our option to use to alternative techniques (subjective judgments), such as the exposure questionnaire, in order to overcome this constrain and to obtain extensive information about the exposure to which workers in these different economic sectors are exposed in their daily work journey. Therefore, the results of the current study should be interpreted with care. The office workers participated worked in Portugal but the prevalence of pain reported was similar to other countries indicating that the data presented is a representative sample to explore the problem.

5.4.5 Conclusion

The present study found a high prevalence of neck pain and a considerable average of the number of body segments with pain in office workers. “Age between 50-65 years”, “number of hours working on a computer without a break”, “screen localization not centered” and “use of computer mouse more than 50% of the worktime” where the significant risk factors associated with the development of neck pain in office worker

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6

Sensitization in office workers with chronic neck pain in different pain conditions and intensities[3]

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6.1 Introduction

Chronic neck pain (CNP) is prevalent in 20-42% of office workers (Janwantanakul et al., 2008; Cunha-Miranda et al., 2010; Madeleine et al., 2010). The 2017 Neck Pain Clinical Guidelines demonstrated weak evidence for diagnosis and classification of neck pain, after the exclusion of a clear pathoanatomical features (Blanpied et al., 2017). The primary International Classification of Diseases-11 (ICD-11) (WHO, 2020) includes codes for idiopathic conditions named chronic primary cervical pain, and for myalgia, as possible causes for neck pain.

Office workers performed monotonous and repetitive tasks mainly on the computer, and work-related myalgia is a common disorder affecting the neck/shoulder area, predominantly affecting the upper trapezius muscle (Juul-Kristesen et al., 2006; Larsson et al., 2007). Trapezius myalgia is characterized by chronic neck pain, tightness, and palpable tenderness in the upper trapezius muscle (Ohlsson et al., 1994; Juul-Kristesen et al., 2006; Larsson et al., 2007).

In chronic primary cervical pain, the mechanisms are non-specific (WHO, 2020). However, pain intensity can be enhanced by central mechanisms without a specific pathology. Understanding the different potential mechanisms between different subgroups may facilitate better treatments tailored to the subgroups (Chimenti et al., 2018).

Pain chronicity is associated with quantitative changes in parameters probing the peripheral or central nervous systems excitabilities (Pavlakovic & Petzke, 2010; Arendt-Nielsen et al., 2011; Pelletier et al., 2015; Chimenti et al., 2018). Quantitative sensory tests (QST) aim to assess sensory function. A reduction of pressure pain threshold (PPT) at a painful local site might reflect localized pressure hyperalgesia. In contrast, a decrease in PPTs at sites distant from the painful areas can reflect widespread pressure hyperalgesia (Arendt-Nielsen et al., 2011, 2018). Temporal summation of pain (TSP) is a human surrogate model that may reflect the wind-up processes in dorsal horn excitability, which is often found facilitated in many chronic pain conditions (Petersen et al., 2015).

Furthermore, assessment of TSP has shown predictive value for outcome after e.g., surgery (Petersen et al., 2015, 2018; Izumi et al., 2017; Kurien et al., 2018), or pharmaceutical interventions (Petersen et al., 2019) and hence may be a clinically relevant parameter (Latremoliere & Woolf, 2009; Arendt-Nielsen et al., 2011). Condition pain modulation (CPM) assesses the balance of descending pain inhibitory and facilitatory mechanisms, and this is often found impaired in severe chronic pain conditions (Yarnitsky et al., 2010; Arendt-Nielsen et al., 2011). Previous studies demonstrated associations in higher clinical pain intensities with more widespread hyperalgesia, facilitated TSP, and impaired CPM (Arendt-Nielsen et al, 2010, 2015a, 2015b).

Pain catastrophizing is associated with higher pain intensity, sleeping problems, and higher levels of depression/anxiety in CNP (Park et al., 2016). In a longitudinal study with a 12-month follow-up, stress, anxiety, and depression are predictors for disability, which is the main predictor for CNP (Moloney et al., 2018). Pain catastrophizing has also been associated with TSP and CPM findings (Quartana et al., 2009), indicating a possible link between cognitive factors and central pain mechanisms.

Office workers with CNP demonstrates signs of widespread hyperalgesia (Johnston et al., 2008), less efficient descending pain modulation (Ge et al., 2014; Shahidi et al., 2015), which could indicate sensitization of central pain pathways. Chronic trapezius myalgia is also associated with widespread hyperalgesia (Leffler et al., 2003; Sjörs et al., 2011), with no clear differences in muscle morphology and physiology comparing with healthy controls (De Meulemeester et al., 2017). Moreover, there is a strong association between pain intensity and perceived muscle tenderness in upper trapezius in office workers (Brandt et al., 2014; Lidegaard et al., 2018). No studies have assessed a wide variety of office workers with different neck pain disorders and assessed the relationship between pain intensity on assessments of central pain pathways.

Thus, the primary aim of this study was to assess PPTs, TSP and CPM in office workers presenting with chronic trapezius myalgia, chronic non-specific neck pain and asymptomatic subjects. In addition, office workers with different pain intensities (mild, moderate and no pain) were assessed. Finally, this study aimed to investigate associations between clinical pain intensities and disability with pain catastrophizing, psychological factors and quantitative sensory tests.

6.2 Methods

6.2.1 Participants

A total of 171 office workers with or without pain in the neck region were recruited to participate. The population was selected as a sub-sample of the 601 office workers from Lisbon University, Algarve University, and Albufeira City Council, who participated in a cross-sectional epidemiological study online survey. In this study, data were collected from February 2018 to May 2019. The eligible criteria were adult office workers from 25-60 years of age, working at least for more than one year in the same job position and working at least 3/4 of the working hours on a computer, as used in previous studies (Johnston et al., 2008; Sjörs et al. 2011; Sjögaard et al., 2010).

The online survey included the Portuguese validated version of the Standardized Nordic Musculoskeletal Questionnaire (Mesquita et al., 2010). Office workers reporting neck-shoulder trouble (pain, ache, or discomfort) for more than 90 days during the last year were assigned to a pain group. Office workers reporting no neck and upper limb symptoms were assigned to the asymptomatic control group. The exclusion criteria for office workers were: medical history of cardiovascular, cerebrovascular events; major chronic diseases; neurologic diseases; metabolic diseases; pregnancy; rheumatologic diseases; fibromyalgia; whiplash disorders; cervical disc herniation or severe disorders of the cervical spine such severe osteoarthritis; and past neck fractures. The symptomatic office workers were excluded if reported more than 30 days of pain in more than three out of eight major body regions (neck/shoulder, low back, and left or right arm/hand, hip, knee, foot) to exclude widespread musculoskeletal diseases (Søgaard et al., 2012; Gerdle et al., 2014).

A standard clinic examination was performed, by one examiner with more than 15 years of clinic experience, to ensure that the subjects met the above criteria. This examination included questions about pain duration (to be considered chronic pain must be present for more than three months); pain intensity; pain localization; tiredness and stiffness in the neck and shoulder region on the day of examination; neck and shoulder range of motion according to Ohlsson and Juul-Kristensen (Ohlsson et al., 1994; Juul-Kristesen et al., 2006). Office workers were asked to not take any analgesics or nonsteroidal anti-inflammatory drugs (NSAIDs) 24 hours before the examination.

The study population was divided into office workers with CNP and asymptomatic office workers. The office workers with CNP were categorized into pain conditions groups and pain intensity groups, each in two groups. The pain conditions groups were divided into chronic trapezius myalgia group and chronic non-specific neck pain group. The pain intensity groups were obtained accordingly with VAS score based on the average pain intensity in the last seven days (mean ± SD pain intensity in VAS: 2.96 ± 1.77), into mild pain group (VAS ≤ 3) and in moderate pain group (VAS >3) (Collins et al., 1997; Petersen et al., 2015). The asymptomatic office workers were assigned as a control group.

The mandatory diagnosis criteria for trapezius myalgia were: (1) chronic neck pain mainly in upper trapezius muscle; (2) tightness of the trapezius muscle (i.e., a feeling of stiffness in the descending region of the trapezius muscle was reported by the subject at the examination of lateral flexion of the head); (3) tenderness on palpation of the upper trapezius muscle; (4) cervical spine was to have non-painful, normal or only slightly decreased range of motion (Nielsen et al., 2010; Sjögaard et al., 2010; Juul-Kristensen et al., 2011). The examination protocol allowed the examiner to identify and exclude the subjects with pain in the trapezius region that was most likely referred from painful tendons or nerve compressions in the neck and shoulder area (Ohlsson et al., 1994; Juul-Kristesen et al., 2006). If there was a decrease in neck range of motion, pain during neck movement, or pain not specific in upper trapezius the condition was considered to be non-specific chronic neck pain. Office workers were considered to be asymptomatic based on VAS score (VAS=0) in the neck and upper limb (Ge et al., 2014), and no more than three body regions with more than 30 days of trouble or pain, both in the online survey and in the clinic examination (Nielsen et al., 2010; Sjögaard et al., 2010).

6.2.2 Demographics and Clinical Characteristics

Demographic variables included were age, gender, BMI, working hours with a computer per week, working hours with computer per day, number of years working with computers, pain intensity, pain duration, analgesics or NSAIDs taking from more than 24 hours for the neck pain, and current treatment for neck pain.

6.2.3 Self-Reported Measures

6.2.3.1 Pain Intensity

The pain intensity at present day and the average in the last seven days as assessed on a Visual Analog Scale (VAS), anchored at 0: no pain and 10: worst pain imaginable.

6.2.3.2 Neck Disability Index

Neck disability index is a 10-item self-reported questionnaire in the following domains: pain intensity, personal care, lifting, reading, headaches, concentration, work, driving, sleeping and, recreation. Each question contains six answer choices, scored 0 (no disability) to 5 (complete disability). Higher scores mean more disability (Vernon & Mior 1991). This questionnaire was translated, adapted, and validated to the Portuguese Language, with a good internal consistency of 0.95 (α Cronbach), high test-retest reliability (ICC=0.90), and good construct validity in a Portuguese population with CNP (Cruz et al., 2015).

6.2.3.3 Pain Catastrophizing Scale

Pain Catastrophizing Scale is a 13-item self-reported measured designed to assess catastrophic thoughts or feelings when experience pain. It is composed with three subscales: rumination, magnification and, helplessness; items are rated on a 5-point scale ranging from 0 (not at all) to 4 (all the time), the maximum score is 52 being 30 points considered to be a clinically relevant level of catastrophizing (Sullivan et al. 1995). This questionnaire was translated, adapted, and validated to the Portuguese population with chronic pain with a good internal consistency in all subscales: rumination (0.796), magnification (0.789), and helplessness (0.897) (Azevedo et al., 2007).

6.2.3.4 Copenhagen Psychosocial Questionnaire II

The long version is designed to assess psychosocial work factors, workers health, and wellbeing, and is composed by 128-item standardized self-reported belonging to 41 scales that represent seven domains (Pejtersen et al., 2010), and the Portuguese version adapted by Silva et al. (2012). In this study, the domain health and wellbeing were used, composed of six scales: burnout, stress, sleeping problems, depressive symptoms, somatic stress, and cognitive stress. The questionnaire included one general health question, with a total of 26 questions. They were scored on a five-point Likert Scale ranging from 1 (not at all) to 5 (all the time), except for the general health question that ranged from 1 (excellent) to 5 (poor). The scales scores were calculated as an average of the items included. Each scale has a good internal consistency between 0.7 to 0.9 in the Portuguese population (Rosário et al., 2017). For easier reading and interpretation, sleeping troubles will be mentioned as sleep.

6.2.4 Quantitative Sensory Testing

6.2.4.1 Pressure Pain Threshold

PPTs were assessed using a hand-held pressure algometer consisted of a 1 cm^2 rubber tip applicator, placed perpendicularly to the skin, mounted on a force transducer at an application rate of 1.0 kgF/s (JTech Medical, Salt Lake City, USA). PPT was defined as the minimum pressure first evoking a sensation of pain. An upper cut-off limit of 500 kPa was used. PPTs were measured twice with an interval of 10 seconds for each point, and the mean value was used for statistical analysis, as previously described (Balaguier et al., 2016).

Four different assessment sites were used: upper trapezius in the most painful side/dominant side and the same point in the contralateral muscle, extensor carpi ulnaris and tibialis anterior. The upper trapezius point was localized in the midpoint between C7 and acromion (Ge et al., 2014); the extensor carpi ulnaris muscle belly point was localized from the lateral epicondyle that was the reference point: 40 mm inferior in a vertical line and then 20 mm posterior (Fernández-Carnero et al., 2010; Ge et al., 2014); the tibialis anterior point was defined approximately 2.5 cm lateral and 5 cm inferior to the tibial tubercle (Manresa et al., 2014). This point was chosen to determine widespread pressure pain hyperalgesia (Johnston et al., 2008; Arendt-Nielsen et al., 2018). The extensor carpi ulnaris and tibialis anterior points were on the same side as the most painful side/dominant side in upper trapezius. For upper trapezius measurement the office workers were in prone position and for extensor carpi ulnaris and tibialis anterior in supine position. Each PPT localization was marked by a pen marker.

6.2.4.2 Temporal Summation of Pain (TSP)

A modified von Frey stimulator (Aalborg University, Aalborg, Denmark) with a weighted load of 25.6 g was used to induce TSP. The procedure consisted of the application on ten consecutive stimulations with a 1-second interval between stimulations, in the upper trapezius on the most painful side/dominant side in the same point previously described with the subjects in a sitting position. Each subject was asked to rate the pain intensity from the first and last stimulus on the VAS (0-10). TSP was calculated as the difference in pain intensity between the first and the last stimuli, as previously described. High TSP scores indicated facilitated temporal summation (Petersen et al., 2015, 2018; Kurien et al., 2018).

6.2.4.3 Conditioned Pain Modulation (CPM)

CPM was measured as the difference in PPTs at the upper trapezius before and after the cold pressor test (CPT) (Petersen et al., 2015). Measurements were done with the subject in a sitting position, the contralateral hand of the most painful side/dominant side immersed up to the wrist in a cold water bath maintained at 2-3ºC. The subjects were asked maintain the hand immersed for a maximum time of 2 minutes or to remove the hand when a pain intensity of 7 out of 10 was reached on a 0 (no pain) to 10 (worst imaginable pain) scale (Manresa et al., 2014). After removing their hand from the cold water, PPT was immediately measured in the upper trapezius.

6.2.5 Experimental protocol

All the quantitative sensory measurements were performed by the principal investigator who was not blinded to group allocation but was blinded to the three questionnaires outcomes (Neck Disability Index, Pain Catastrophizing Scale, Copenhagen Psychosocial Questionnaire II). A code was introduced for each group for the statistical analyzes assessor remain blinded to group allocation. After the clinic examination the sequence of the quantitative sensory procedures were: 1) PPT measured in the upper trapezius in the most painful side/dominant, the same point in the contralateral muscle, in the extensor carpi ulnaris and in the tibialis anterior (ipsilateral); 2) TSP measurement; 3) CPM assessment. There was a five-minute interval between PPT and TSP and between TSP and CPM.

6.2.6 Statistics

Descriptive statistics were calculated for age, gender, BMI, number of working hours per week, number of working hours on the computer and number of years working on the computer. The Kolmogorov–Smirnov test was used for normality assessment, and all data were normally distributed. Unpaired *t*-test was used to compare differences between the symptomatic groups for pain intensity (current pain and pain within the last 7 days), pain duration, analgesics or NSAIDs taking from more than 24 hours for the neck pain, and current treatment for neck pain, NDI and PCS. Descriptive statistics are reported as means ± standard deviation (SD), and 95% confidence interval in text and tables.

Univariate analysis of covariance (ANCOVA), with covariate adjustment for gender, was used to determine differences between groups for PPT, TSP and Copenhagen Psychosocial Questionnaire II. A two-way repeated measure mixed ANCOVA (gender as a covariate) was conducted comparing the differences in PPT over time for CPM in pain conditions groups and pain intensity groups. The Tukey post hoc test was used in case of significant factors ($p<0.05$). Pearson's product-moment correlation was used to assess the associations between pain intensity and disability, with PPT, TSP, CPM, Pain Catastrophizing Scale and Copenhagen Psychosocial Questionnaire II variables in the symptomatic groups. For each dependent variable, pain intensity and disability, a backward stepwise multiple regression analysis was employed considering as candidate predictors the variable gender and the ones that present a significant correlation ($p<0.05$) with the dependent variable.

The prevalence rate of Portuguese office workers with CNP is 19.2% (Cunha-Miranda et al., 2010). The sample size was determined based on the number of available surveys (n=601) from a previous cross-sectional study without a priori power calculation. Considering a 95% confidence interval with a 5% margin of error, and a desired power of 80%, originates the total sample size of 171 office workers needed for the current study.

The statistical analysis was conducted using SPSS 25.0 software (SPSS Inc., Chicago, IL, USA).

6.3 Results

6.3.1 Office Workers Demographics

One-hundred–and-seventy-one office workers (age 43.3±7.9; 41 males and 135 females, weight 67.5±13.2 kg, height 165.7±8.7 cm) were enrolled from the Albufeira City Council (59.1%), from the Lisbon University (28.7%), and from Algarve University (12.2%). The office workers with CNP were categorized into subjects with chronic trapezius myalgia (n=56) and chronic non-specific neck pain (n=53); and into mild pain (n=60) and moderate pain (n= 49) (flow-chart in fig 6.1). Asymptomatic subjects were classified as controls (n=62). See table 6.1 and 6.2 for demographic information.

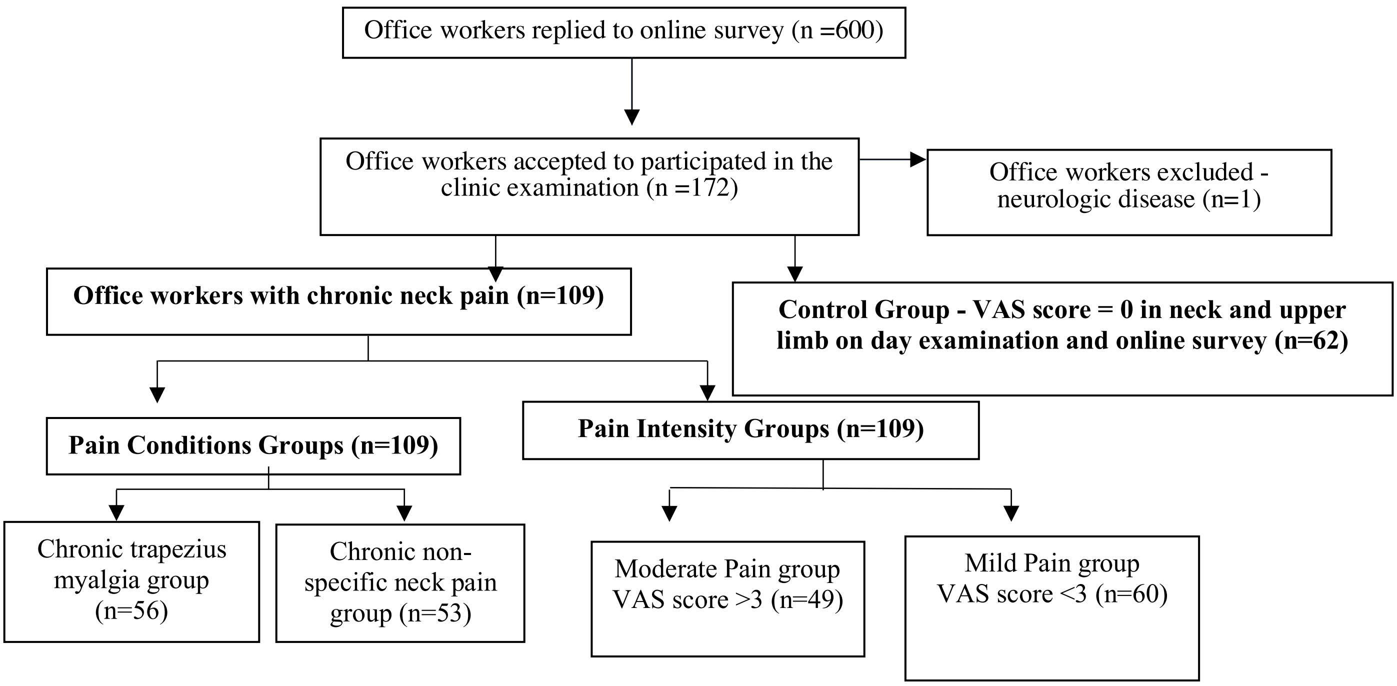


Fig. 6.1 – Flowchart diagram of office workers

Females were more frequently found in the symptomatic groups compared with asymptomatic office workers (see table 6.1 and 6.2). A secondary analysis of gender within and between groups was conducted for the exposure factors and pain variables (intensity and duration). There were no differences in pain variables within all groups. In the moderate pain group, males work more time per week and more hours at a computer per day (*p*=0.25, *p*=0.04, respectively). In the control group, females were older compared with males (p=0.19). Between groups pain at present day was higher in chronic trapezius myalgia compared with non-specific chronic neck pain (p=0.01), and also in moderate pain group compared with mild pain group (p<0.001). In the moderate pain group females work less hours per day at computer compared with mild pain group and controls group (p=0.037) (Appendix 1).

The chronic trapezius myalgia group had a higher analgesic consumption (more than 24 hours) (p=0.026) and higher clinical pain intensity at the present day (*p*=0.009) comparing with chronic non-specific neck pain group (table 6.1). The moderate pain group had higher clinical pain intensity at the present day (*p*<0.0001) comparing with mild pain group (table 6.2).

Table 6.1 – Descriptive characteristics of office workers in Pain Condition Groups.

Variable	**Chronic trapezius myalgia (n=56)**	**Chronic non-specific neck pain (n=53)**	**Controls (n=62)**	***P***
Age (years)	42.80 ± 7.3	45.45 ± 7.9	43.09 ± 8.3	0.162
Sex, n (%) female/male	50 (89.3%) / 6 (10.7%)	47 (88.7%) / 6 (11.3%)	38 (61.3%) / 24 (38.7%)	**<0.001**[a]
BMI (kg/m²)	24.17 ± 3.83	24.22 ± 3.09	24.88 ± 3.80	0.537
Working time (h/wk)	36.80 ± 4.5	37.15 ± 7.6	38.22 ± 6.0	0.422
Computer work (h/day)	6.56 ± 1.2	6.18 ± 1.1	6.48 ± 1.3	0.310
Computer work (years)	15.89 ± 7.7	18.03 ± 8.7	18.11 ± 7.6	0.250
VAS (0-10 cm) (present day)	2.31±1.80	1.44±1.58	NA	**0.009**[b]
VAS (0-10 cm) (last 7 days)	3.27 ± 1.742	2.65 ± 1.78	NA	0.069

Variable	**Chronic trapezius myalgia (n=56)**	**Chronic non-specific neck pain (n=53)**	**Controls (n=62)**	***P***
Pain duration (months)	77.92 ± 63.73	90.94 ± 67.03	NA	0.301
Analgesic + 24 hour *n* (%) yes/no	15 (26.8%) / 41 (73.2%)	5 (9.4%) / 48 (90.6%)	NA	**0.026**[b]
Treatment *n* (%) yes/no	5 (8.9%) / 51 (91.1%)	7 (13.2%) / 46 (86.8%)	NA	0.550
Pain < 3 and >3 VAS (0-10) n/%	29 (51.8%) / 27 (48.2%)	31 (58.5%) / 22 (41.5%)	NA	0.482

Data are expressed as mean ± SD of the mean, or in percentage frequencies (%).

Bold indicates significant (p<0.05).

[a] Between controls group with chronic trapezius myalgia and chronic non-specific neck pain groups, χ^2 test.

[b] Between chronic trapezius myalgia with chronic non-specific neck pain, unpaired *t*-test

Abbreviations: NA=not available; VAS=Visual Analog Scale.

Table 6.2 – Descriptive characteristics of office workers in Pain Intensity Groups.

Variable	**Mild pain (n=60)**	**Moderate pain (n=49)**	**Controls (n=62)**	***P* value**
Age (years)	44.21 ± 7.7	43.93 ± 7.7	43.0 ± 8.3	0.719
Sex, n (%) female/male	52 (86.7%) / 8 (13.3%)	45 (91.8%) / 4 (8.2%)	38 (61.3%) / 24 (38.7%)	**<0.0001**[a]
BMI (kg/m²)	23.97 ± 3.63	24.47 ± 3.29	24.88 ± 3.80	0.347
Working time (h/wk)	37.93 ± 5.9	35.79 ± 6.3	38.22 ± 6.0	0.122
Computer work (h/day)	6.37 ± 1.0	6.34 ± 1.4	6.48 ± 1.3	0.882
Computer work (years)	17.31 ± 8.0	16.46 ± 8.5	18.11 ± 7.6	0.863
VAS (0-10 cm) (present day)	1.18±1.02	2.76±.2.04	NA	**<0.0001**[b]

Variable	**Mild pain (n=60)**	**Moderate pain (n=49)**	**Controls (n=62)**	***P* value**
VAS (0-10 cm) (last 7 days)	1.60 ± .86	4.62 ± .94	NA	**<0.0001[b]**
Pain duration (months)	86.83 ± 71.36	81.60 ± 58.02	NA	0.088
Analgesic + 24 hour *n* (%) yes/no	8 (13.3%) / 52 (86.7%)	12 (24.5%) / 37 (75.5%)	NA	0.146
Treatment *n* (%) yes/no	10 (16.7%) / 50 (83.3)	2 (4.1%) / 47 (95.9%)	NA	0.062

Data are expressed as mean ± SD of the mean, or in percentage frequencies (%).
Bold indicates significant (p<0.05).
[a] Between controls group with mild pain and moderate pain groups, χ^2 test.
[b] Between moderate pain group with mild pain group, unpaired *t*-test.
Abbreviations: NA=not available; VAS=Visual Analog Scale;

6.3.2 Self-Reported Measures

6.3.2.1 Neck Disability Index

In the pain condition groups, there was a significant difference in disability, $t(107)=2.017$, $p=0.046$, with higher neck disability index in the chronic trapezius myalgia group (*M*=10.4, *SD*=4.9) compared with chronic non-specific neck pain group (*M*=8.6, *SD*=4.2) (table 6.3).

In the pain intensity groups, there was a significant difference in disability, $t(107)=4.22$, $p<0.001$, with higher neck disability index in the moderate pain group (*M*=11.5, *SD*=4.9) compared with mild pain group (*M*=8.0, *SD*=3.8) (table 6.4).

6.3.2.2 Pain Catastrophizing Scale

No significant differences was found comparing the pain condition groups [$t(107)=1.752$, $p=0.083$] and the pain intensity groups [$t(107)=.645$, $p=0.519$] (table 6.3 and 6.4).

Table 6.3 – Self-reported measures in pain condition groups.

Variables	Chronic trapezius myalgia (n=56)		Chronic non-specific neck pain (n=53)		Controls (n=62)		Test Statistic
	M (SD)	95% CI	*M* (SD)	95% CI	*M* (SD)	95% CI	
NDI (0-50)	10.4 (4.9)	[1.0, 23.0]	8.6 (4.21)	[1.0, 18.0]	-	-	t = 2.01[a]
PCS (0-52)	15.3 (10.7)	[0.0, 40.0]	11.9 (9.94)	[0, 39.0]	-	-	t = 1.75
Copenhagen Psychosocial Questionnaire II							
Sleep (1-5)	2.5 (.90)	[2.2, 2.7] [b]	2.5 (.80)	[2.3, 2.8] [c]	1.9 (.78)	[1.7, 2.1]	*F*=9.48
Burnout (1-5)	2.9 (.90)	[2.7, 3.1] [b]	2.7 (.78)	[2.5, 2.9] [c]	2.3 (.79)	[2.1, 2.5]	*F*=8.07
Stress (1-5)	3.0 (.78)	[2.8, 3.2] [b]	2.7 (.76)	[2.5, 2.9] [c]	2.4 (.74)	[2.2, 2.6]	*F*=10.68
Depression symptoms (1-5)	1.9 (.66)	[1.7, 2.1] [b]	2.0 (.73)	[1.8, 2.2] [c]	1.6 (.53)	[1.5, 1.8]	*F*=5.06
Somatic Stress (1-5)	2.3 (.72)	[2.1, 2.5] [b]	2.1 (.59)	[1.9, 2.3] [c]	1.7 (.50)	[1.6, 1.8]	*F*=15.20
Cognitive Stress (1-5)	2.4 (.67)	[2.2, 2.6] [b]	2.4 (.68)	[2.2, 2.6] [c]	2.1 (.66)	[1.9, 2.2]	*F*=4.33

[a] Between chronic trapezius myalgia group with chronic non-specific neck pain, independent *t*-test, (p=0.046); [b] Between chronic trapezius myalgia group with controls group, Tukey post hoc (p <0.05); [c] Between chronic non-specific neck pain with controls group, Tukey post hoc (p <0.05)

Abbreviations: NDI= Neck Disability Index; PCS= Pain Catastrophizing Scale.

Table 6.4 – Self-reported measures in pain intensity groups.

Variable	Mild Pain (n=60)		Moderate Pain (n=49)		Controls (n=62)		Test Statistic
	M (SD)	95% CI	*M* (SD)	95% CI	*M* (SD)	95% CI	
NDI (0-50)	8.0 (3.8)	[1.0, 16.0]	11.5 (4.9)	[.1.0, 23.0]	-	-	t= 4.22[a]
PCS (0-52)	13.1 (10.2)	[0, 36.0]	14.4 (10.7)	[.0.0, 40.0]	-	-	t= .62
Copenhagen Psychosocial Questionnaire II							
Sleep (1-5)	2.3 (.78)	[2.1, 2.5] [c]	2.7 (.90)	[2.4, 3.0] [b]	1.9 (.78)	[1.7, 2.1]	*F*=12.12
Burnout (1-5)	2.7 (.83)	[2.4, 2.9]	3.0 (.82)	[2.8, 3.2] [b]	2.3 (.79)	[2.1, 2.5]	*F*=9.80
Stress (1-5)	2.7 (.76)	[2.5, 2.9] [c]	3.0 (.77)	[2.8, 3.3] [b]	2.4 (.74)	[2.2, 2.6]	*F*=11.18
Depression symptoms (1-5)	1.9 (.67)	[1.7, 2.1] [c]	2.0 (.73)	[1.7, 2.2] [b]	1.6 (.53)	[1.5, 1.8]	*F*=4.92
Somatic Stress (1-5)	2.1 (.63)	[1.9, 2.2] [c]	2.4 (.67)	[2.2, 2.5] [b, d]	1.70 (.50)	[1.6, 1.8]	*F*=17.68
Cognitive Stress (1-5)	2.4 (.69)	[2.2, 2.5]	2.4 (.66)	[2.2, 2.6] [b]	2.1 (.66)	[1.9, 2.2]	*F*=4.55

[a] Between moderate pain group with mild pain group, independent *t*-test, (p<0.001); [b] Between moderate pain group with controls group, Tukey post hoc (p <0.05); [c] Between mild pain group with controls group, Tukey post hoc (p <0.05); [d] Between moderate pain group with mild pain group, Tukey post hoc (p <0.05)

Abbreviations: NDI= Neck Disability Index; PCS= Pain Catastrophizing Scale.

6.3.2.3 Copenhagen Psychosocial Questionnaire II

In the pain conditions groups, there was a significant difference in all variables (p<0.05), with higher values in chronic trapezius myalgia and chronic non-specific neck pain groups compared with control group (table 6.3).

In the pain intensity groups, there was a significant difference in sleep, burnout, stress, depression symptoms and somatic stress (p<0.05), with higher values in the moderate pain and mild pain groups compared with control group. In addition, somatic stress was higher in the moderate pain compared with mild pain groups (p=0.030), and in cognitive stress was higher in the moderate pain group compared with control group (p=0.013) (table 6.4).

6.3.3 Quantitative Sensory Testing

6.3.3.1 Pressure Pain Thresholds

In the pain conditions groups, significant lower PPTs were found in the upper trapezius at the painful/dominant side [F (2,165) = 15.184, p <0.001], and the contralateral side [F (2,165)=8.439, p <0.001]. Post hoc analysis showed lower PPTs in the chronic trapezius myalgia group comparing with chronic non-specific neck pain group (p<0.021) and control group (p<0.001), and lower PPTs in the chronic non-specific neck pain group comparted with control (p<0.08). Significant lower PPTs were found at extensor carpi ulnaris [F (2,165)=5.250, p<0.0001]. Post hoc analysis showed lower PPTs in the chronic trapezius myalgia group comparing with chronic non-specific neck pain group (p=0.05) and control group (p<0.001). Significant lower PPTs were found at tibialis anterior [F (2,165)=5.259, p=0.006] in the chronic trapezius myalgia group compared with control group (p<0.011) (fig. 6.2a).

In the pain intensity groups, significant lower PPTs were found at both the painful/dominant side [F (2,165)=11.696, p<0.0001] and contralateral side [F (2,165)=7.102, p=0.001] of upper trapezius. Post hoc analysis showed lower PPTs in the moderate pain and mild pain groups compared with control group (p<0.0001). Significant lower PPTs were found at extensor carpi ulnaris [F (2,165)=3.322, p=0.039]. Post hoc analysis showed lower PPTs in the moderate pain and mild pain groups compared with control group (p<0.013). Significant lower PPTs were found at tibialis anterior [F (2,165) = 5.430, p =0.005], in moderate pain group compared with control group (p<0.0001) (fig 6.2b).

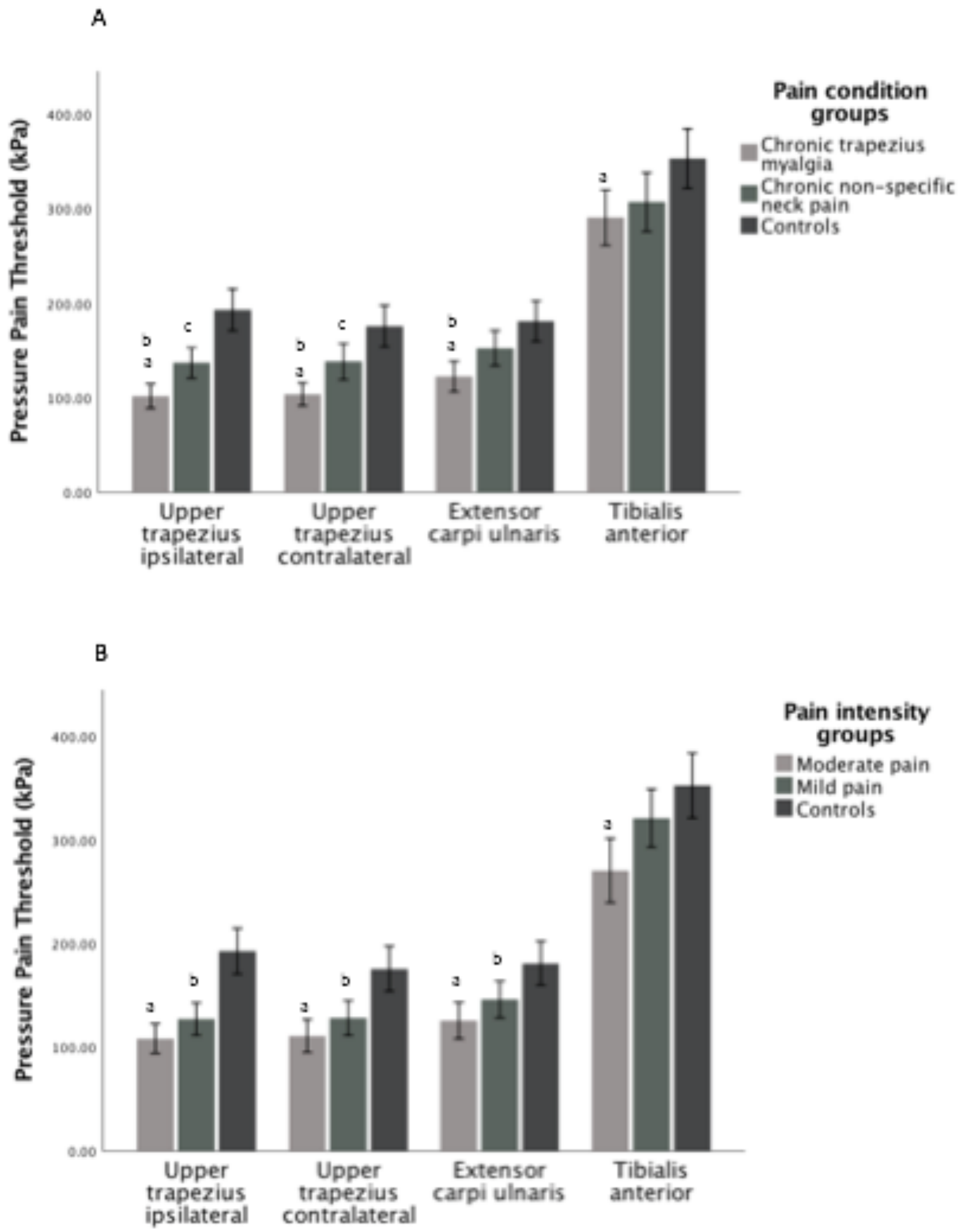


Figure 6.2 – Pressure pain threshold (PPTs) measured at upper trapezius (ipsilateral and contralateral), extensor carpi ulnaris and tibialis anterior.

(A) Pain Condition Groups; a Indicates significant differences ($p<0.05$) between chronic trapezius myalgia group with controls group. b Indicates significant differences ($p<0.05$) between chronic trapezius myalgia group with chronic non-specific neck pain group. c Indicates significant differences ($p<0.05$) between chronic non-specific neck pain group with controls group. (B) Pain Intensity Groups; a Indicates significant differences ($p<0.05$) between moderate pain with controls group. b Indicates significant differences ($p<0.05$) between mild pain with controls group. Error bars represent SE.

6.3.3.2 Temporal Summation of Pain

No statistical difference was found comparing the pain condition groups (fig. 6.3). In the pain intensity groups, there was a significant higher TSP [*F* (2,156)=5.523, *p* <0.0001]. Post hoc analysis showed a higher TSP in the moderate pain group compared with mild pain group (*p* <0.001) and control group (*p* <0.001) (fig. 6.3).

A

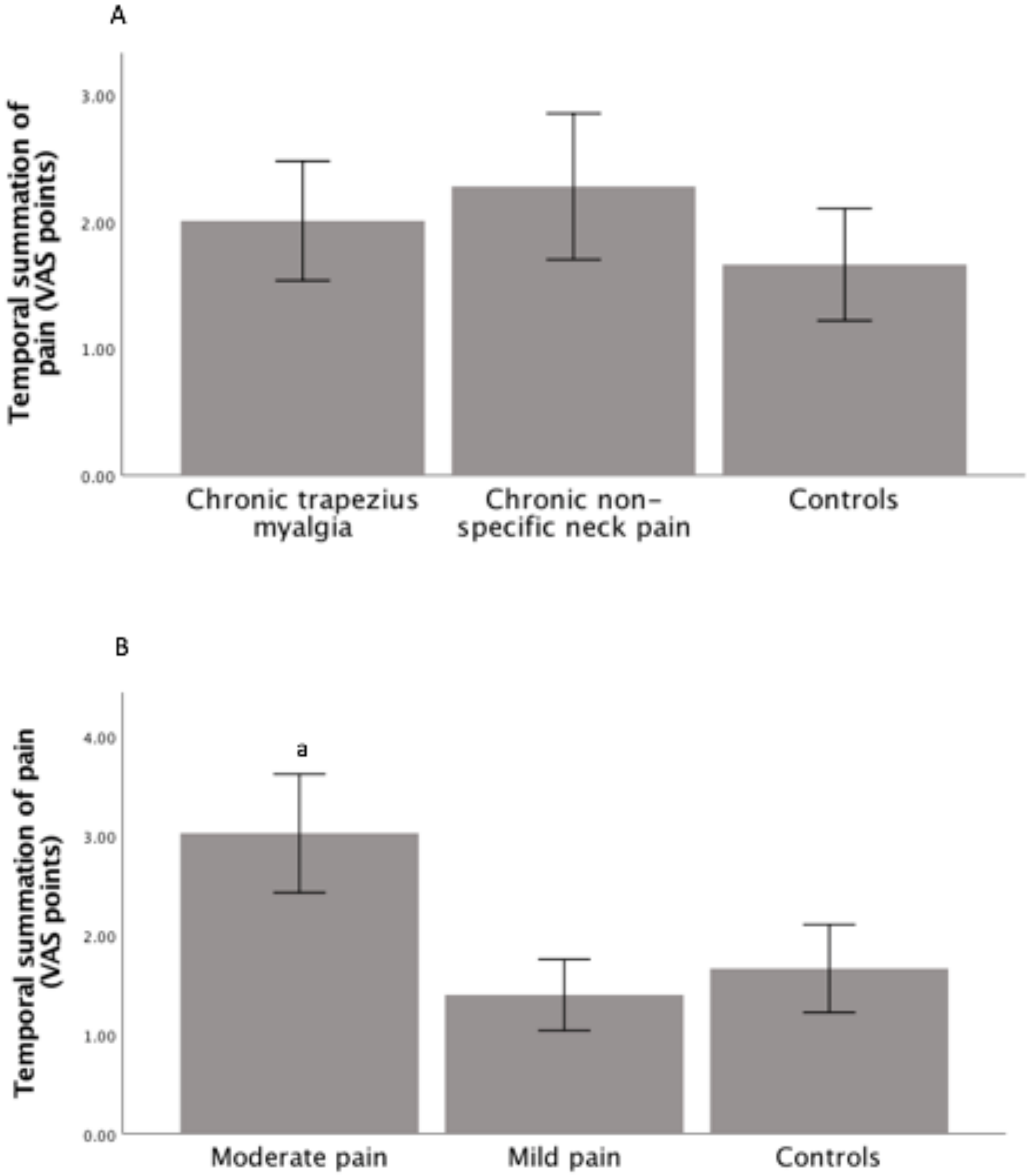


Fig 6.3 – Temporal summation of pain

(A) Pain Condition Groups; no statistical differences between groups. (B) Pain Intensity Groups; a Indicates significant differences (p<0.001) between moderate pain with mild pain and controls groups. Error bars represent SE.

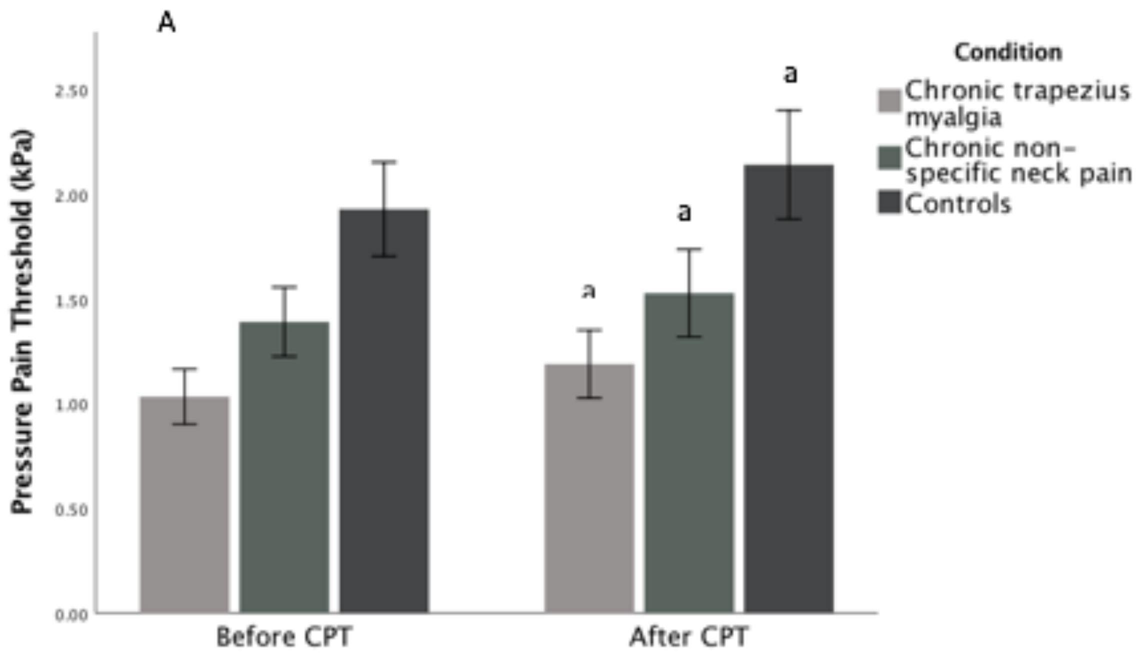
6.3.3.3 Conditioning Pain Modulation

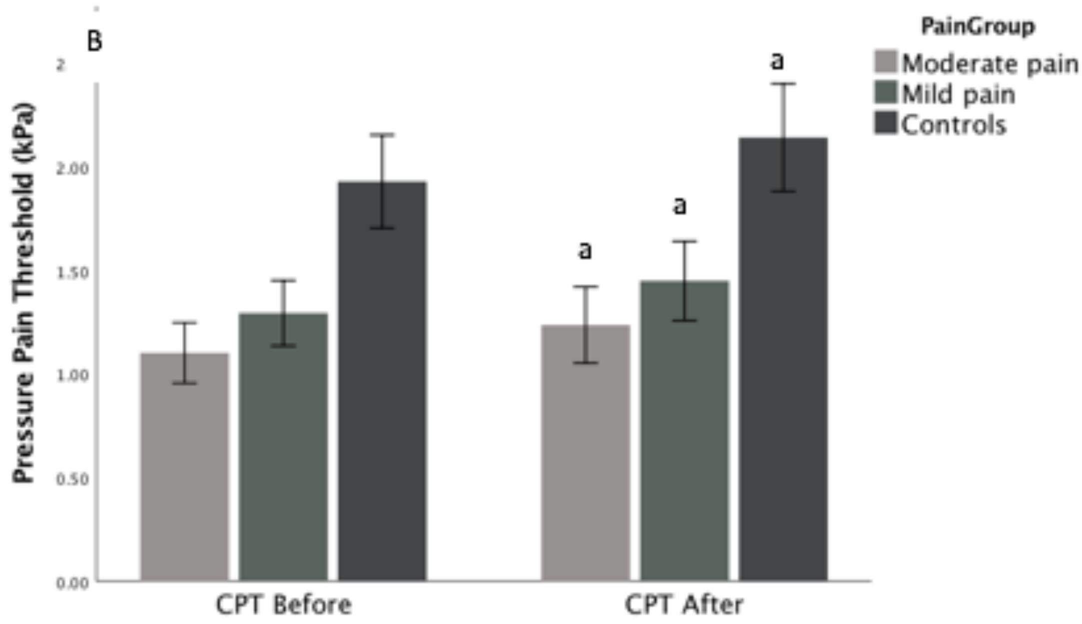
The average water temperature was 2.90±0.95 Cº, the average hand immersion time in the cold water was 56.19±39.48 sec, and the average pain intensity rated after the cold water was 5.76±2.22 on the VAS. There was a significant difference in hand immersion time being higher in the asymptomatic group compared with all the symptomatic groups (p<0.005), and the moderate pain group reported a higher pain intensity from the cold water comparing with the mild pain group (p=.011).

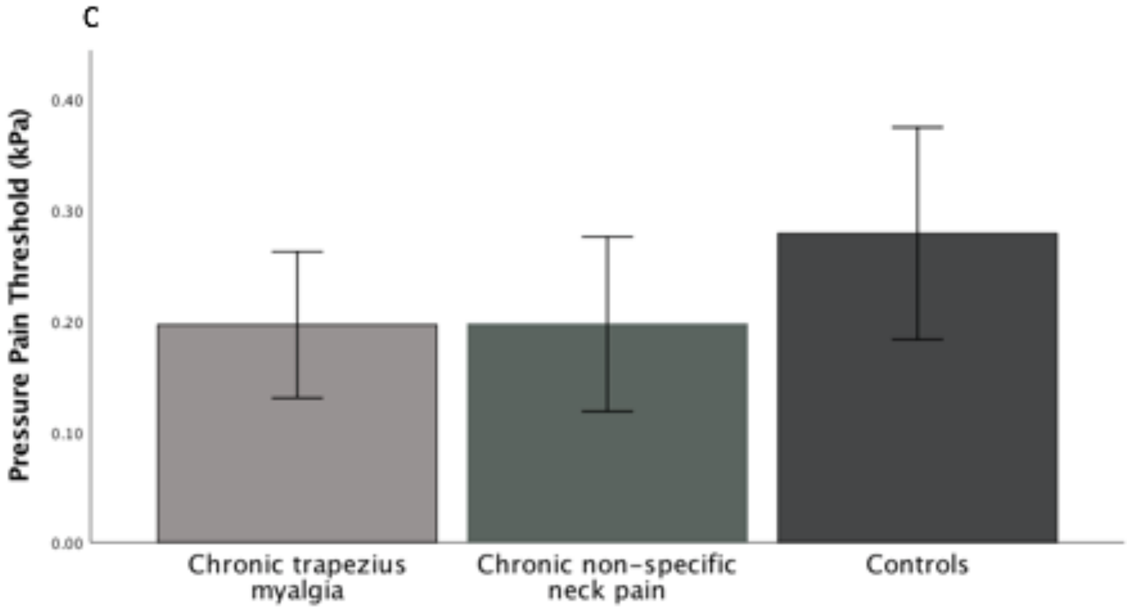
There was a significant difference in PPT over time in the pain conditions groups [$F(2,165)=13.754$, $p<0.0001$], and in the pain intensity groups [$F(2,165)=9.320$, $p<0.0001$], but post hoc analysis of the groups shown no significant differences. The post-hoc analysis on PPTs before and after the cold pressor test, revealed that PPTs after the cold pressor test compared to baseline assessment were significantly higher for all groups ($p<0.05$) as an indicator of efficient CPM (figure 6.4).

For the CPM effect there was a higher effect without significant difference in controls group compared with pain conditions groups [$F(2,165)=0.915$, $p=0.402$], and with pain intensity groups [$F(2,165)=0.108$, $p=0.898$] (figure 6.4).

Pooling all office workers with chronic neck pain and compared with controls there was a significant difference in PPT over time in both groups [$F(1,169)=27.990$, $p<0.0001$]. PPTs were significantly higher for both groups after the cold pressor test ($p<0.0001$) as an indicator of efficient CPM (figure 6.4).




B
PainGroup
Moderate pain
Mild pain
Controls
Pressure Pain Threshold (kPa)
2
2.00
1.50
1.00
0.50
0.00
a
a
a
CPT Before
CPT After


C
Pressure Pain Threshold (kPa)
0.40
0.30
0.20
0.10
0.00
Chronic trapezius myalgia
Chronic non-specific neck pain
Controls

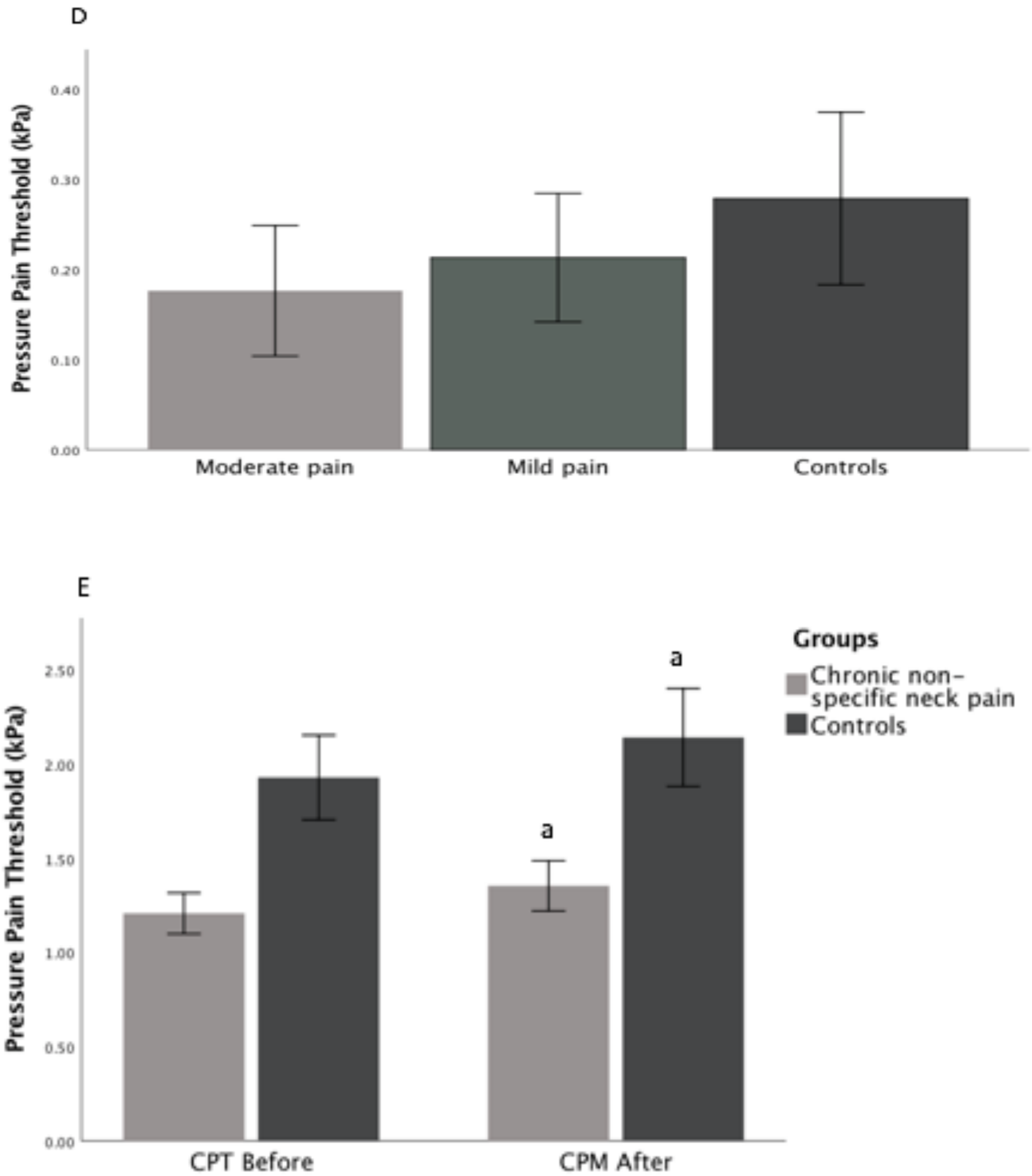


Fig. 6.4 – Pressure pain threshold (PPTs) assessed at upper trapezius in the most painful side/dominant side before and after the cold pressor test (conditioned pain modulation).

(A) Pain Condition Groups. (B) Pain Intensity Groups. a Indicates significant differences (p<0.05) in PPTs were observed after the cold pressure test as compared with before within all groups, but not between groups. (C) CPM effect in Pain Condition Groups. (D) CPM effect in Pain Intensity Groups. (E) All office workers with chronic pain pooled together compared with controls. a Indicates significant differences (p<0.05) in PPTs were observed after the cold pressure test as compared with before within all groups, but not between groups. Error bars represent SE. CPT, cold pressure test.

6.3.3.4 Pain intensity association with self-reported measures and quantitative sensory testing.

In the pain conditions groups, significant positive correlations were found between pain intensity and neck disability index and TSP in the chronic trapezius myalgia group and in the chronic non-specific neck pain group. In addition, a positive association between sleep, cognitive stress, somatic stress with clinic pain intensity were found in the chronic trapezius myalgia group. Significant negative correlation were found for PPTs in upper trapezius contralateral point, extensor carpi ulnaris and tibialis anterior with clinical pain intensity in chronic trapezius myalgia group (table 6.5).

Table 6.5 – Pearson Correlation between pain intensity with self-reported measures and quantitative sensory testing.

Variable	Pain Condition Groups		Pain Intensity Groups	
	Chronic trapezius myalgia	Chronic non-specific neck pain	Mild pain	Moderate pain
	R	R	R	R
Self-reported outcomes				
Neck Disability Index	.523**	.381**	.347**	.296*
Pain Catastrophizing Scale	.151	.071	.057	.275
Copenhagen Psychosocial Questionnaire II				
Sleep	.308*	.175	.161	.058
Burnout	.236	.195	.044	.195
Stress	.295*	.179	.081	.276
Depression symptoms	-.033	.049	-.159	.057
Somatic Stress	.273*	.230	.145	.162
Cognitive Stress	.198	-.050	-.150	.253
Quantitative sensory testing				
PPT upper trapezius (ipsilateral)	-.213	-.152	-.096	-.225
PPT upper trapezius (contralateral)	-.284*	-.080	-.073	-.220
PPT extensor carpi ulnaris	-.279*	-.052	-.008	-.232
PPT tibialis anterior	-.399**	-.201	-.189	-.268
TSP	.414**	.363**	-.059	.037
CPM	-.146	.075	.141	-.157

**p*<0.05, ** *p*<0.001. Abbreviations: CPM= conditioned pain modulation; PPT= pressure pain threshold; TSP= temporal summation of pain.

In the pain intensity groups, a significant positive correlation was found between clinical pain intensity with neck disability index in moderate pain and mild pain groups (table 5)

The linear multiple stepwise regression showed that disability and TSP were independent parameters associated with clinic pain intensity, in chronic trapezius myalgia group, $F(2,50)=13.171$, $p<.0001$, adj. $R^2=.319$ and in CNP $F(2,47)=7.439$, $p=.002$, adj. $R^2=.208$. Regression coefficients and standard errors can be found in table 6.6.

Table 6.6. Multivariate regression models for pain intensity in pain condition groups.

	Adj. R^2	***F***	**Independent Variables**	***B***	***SE B***	***β***	***p***
Chronic trapezius myalgia group							
Overall model	.319	13.171					
			Neck Disability Index	.150	.041	.444	.001[b]
			TSP	.256	.119	.262	.037[a]
Chronic non-specific neck pain group							
Overall model	.208	7.439					
			Neck Disability Index	1.35	.052	.331	.013[a]
			TSP	.288	.110	.335	. 012[a]

[a] p*<0.05,* [b] p *<0.001.* Abbreviations: TSP= Temporal Summation of Pain.

6.3.4 Disability association with self-reported measures and quantitative sensory testing.

Significant negative correlations were found between disability and PPTs, in all points in the chronic trapezius myalgia and in the moderate pain groups, and between upper trapezius at the most painful side and tibialis anterior in chronic non-specific neck pain group. A positive correlation between disability with TSP was found in chronic trapezius myalgia group and most of the Copenhagen Psychosocial Questionnaire subscales (sleep, burnout, stress, somatic stress and cognitive stress) and in the pain catastrophizing scale in all groups (table 6.7).

The linear multiple stepwise regression showed that somatic stress was the independent parameters associated with disability, $F(1,54)=15.772$, $p<.0001$, adj. $R^2=.212$ in chronic trapezius myalgia group. Somatic stress, cognitive stress and sleep were an independent predictor for disability ($F(3,49)=20.168$, $p<.0001$, adj. $R^2=.525$) in chronic non-specific neck pain group. Regression coefficients and standard errors can be found in table 6.8.

In the pain intensity groups, the linear multiple stepwise regression showed that stress was the independent parameter associated with disability $F(1,47)=47.776$, $p<.0001$, adj. $R^2=.494$ in moderate pain group. Somatic stress and sleep $F(2,57)=11.447$, $p<.0001$, adj. $R^2=.262$ were independent predictors of disability in the mild pain group. Regression coefficients and standard errors can be found in table 6.8.

Table 6.7 – Pearson Correlation between disability with self-reported measures and quantitative sensory testing.

Variable	Pain Condition Groups		Pain Intensity Groups	
	Chronic trapezius myalgia	Chronic non-specific neck pain	Mild pain	Moderate pain
	R	R	R	R
Self-reported outcomes				
Pain Catastrophizing Scale	.309*	.391**	.259*	.468**
Copenhagen Psychosocial Questionnaire II				
Sleep	.372**	.564**	.427**	.375**
Burnout	.370**	.542**	.323*	.510**
Stress	.451**	.662**	.347*	.710**
Depression symptoms	.141	.422**	.194	.328*
Somatic Stress	.475**	.557**	.456**	.509**
Cognitive Stress	.443**	.346*	.343**	.458**
Quantitative sensory testing				
PPT upper trapezius (ipsilateral)	-.359**	-.277*	-.230	-.428**
PPT upper trapezius (contralateral)	-.383**	-.241	-.231	-.383**
PPT extensor carpi ulnaris	-.313*	-.186	-.192	-.305*
PPT tibialis anterior	-.312*	-.352**	-.253	-.304*
TSP	.343*	.084	.030	.067
CPM	-.147	.097	.001	-.024

*$p<0.05$, ** $p<0.001$. Abbreviations: CPM= conditioned pain modulation; PPT= pressure pain threshold; TSP= temporal summation of pain.

Table 6.8 - Multivariate regression models for disability in pain condition groups and pain intensity groups.

	Adj. R^2	***F***	**Independent Variables**	***B***	***SE B***	***β***	***p***
Pain Condition Groups							
Chronic trapezius myalgia							
Overall model	.212	15.772					
			Somatic Stress	3.224	.812	.475	.0001[c]
Chronic non-specific neck pain							
Overall model	.525	20.168					
			Somatic Stress	1.760	.835	.246	.040 [a]
			Stress	2.057	.703	.373	.005[b]
			Sleep	1.556	.574	.299	.009[b]
Pain Intensity Groups							
Moderate pain group							
Overall model	.494	47.776					.
			Stress	4.440	.642	.710	.0001[c]
Mild pain group							
Overall model	.262	11.447					
			Somatic Stress	2.115	.731	.347	.005[b]
			Sleep	1.471	.588	.300	.015[a]

[a] $p<0.05$, [b] $p<0.01$, [c] $p<0.001$

6.4 Discussion

Widespread pressure hyperalgesia was found in chronic trapezius myalgia and in the moderate pain intensity groups when compared with asymptomatic office workers. In addition, temporal summation was facilitated in the moderate pain group compared with the mild pain group and asymptomatic office workers. Further, no differences in conditioning pain modulation were found across the different pain conditions or different pain intensities. Finally, disability and temporal summation of pain were independently predictors for pain intensity in pain conditions groups, and stress, somatic stress and sleep were independent predictors for disability.

6.4.1 Assessment of central pain mechanisms in chronic neck pain

Widespread hyperalgesia has been reported in a number of painful conditions (Arendt-Nielsen et al., 2018), but the evidence for widespread hyperalgesia in CNP in office workers is conflicting. Ge et al. (2014), found no differences in PPTs in upper trapezius, extensor carpi ulnaris and tibialis anterior in office workers with CNP compared with healthy controls. Similar, Heredia-Rizo et al. (2019) found no differences in PPTs in upper trapezius and extensor carpi ulnaris in office workers with and without pain. Johnston et al. (2008) demonstrated signs of widespread hypersensitivity in moderate/severe pain and disability group compared with the milder pain and disability group, with no disability group and control group. Nielsen et al. (2010) demonstrated lower PPTs in upper trapezius and tibialis anterior in office workers with chronic trapezius myalgia compared with healthy workers. The current study demonstrated localized and widespread pressure hyperalgesia in the moderate pain and chronic trapezius myalgia groups as compared with asymptomatic controls. In addition, all the symptomatic groups had lower PPTs in upper trapezius compared with asymptomatic controls, indicating the presence of localized pressure hyperalgesia in office workers with CNP. The current study adds to the literature that specific subgroups of office workers might display widespread pressure hyperalgesia.

Facilitated TSP might be indicative of the sensitivity of dorsal horn neurons, as shown in animal models of muscle pain (Sluka & Mense, 2013). Facilitated TSP has been found in many severe chronic pain conditions (Arendt-Nielsen et al., 2010, 2015a, 2018), and studies have found that a long pain duration (years with chronic pain) and increasing clinical pain intensity are associated with facilitated TSP (Arendt-Nielsen et al., 2010, 2015a, 2018). Recently, Heredia-Rizo et al. (2019) showed no differences in TSP comparing officer workers with and without pain. The current study found facilitated TSP in the moderate pain group compared with the mild pain group and asymptomatic subjects, which could support that increasing clinical pain intensity is associated with facilitated TSP in CNP. In our regression model, TSP was one of the independent variables that explained pain intensity in chronic trapezius myalgia and chronic non-specific neck pain groups. To our knowledge, the current study and the study from Heredia-Rizo et al. (2009) are the only studies that assessed TSP in this specific population.

CPM is impaired in multiple chronic pain conditions when compared to pain-free subjects (Petersen et al., 2015), and it seems likely that multiple factors can affect CPM such as physical activity (Naugle & Riley, 2014) or the use of opioids (Martel et al., 2019). Heredia-Rizo et al. (2019) found that CPM was similar to comparing office workers without pain and with moderate pain intensities, which was similar to Ge et al. (2014) and the current study. Shahidi et al. (2015) and Shahidi and Maluf (2017), found that the assessment of CPM was a risk factor for pain at 12 months follow-up in patients with CNP, which could indicate that some office workers with pain might display impaired CPM. Further studies are needed to investigate the role of CPM in neck and shoulder pain and to a possible predictive role for chronicity of neck and shoulder pain.

6.4.2 Pain Intensity and Disability

Neck and low back pain are the worldwide leading cause of disability (Vos et al., 2016), and neck pain alone causes a significant disability (Vos et al., 2012; Hoy et al., 2014). In office workers with CNP the average of self-reported productivity loss ranged between 20% to 32% (Hagberg et al., 2002; van de Heuvel., 2007), and the inability to perform daily work due to neck and shoulder pain was also reported by office workers of both sexes (Madeleine et al., 2013).

In the current study, disability was an independent variable associated with pain intensity in all symptomatic groups. Furthermore, our regression model showed that the independent variables stress, somatic stress, and sleep explained from 21,2% up to 52.5% of the disability in all the symptomatic groups. In three prospective studies, stress, disability, and pain intensity were associated with CNP in workers (Fanavoll et al., 2016; Moloney et al., 2018; Svedemark et al., 2018). In the large cohort longitudinal study from Fanavoll et al. (2016), with a follow-up of 11 years with more than 25.000 workers without neck pain, perceived work stress was a predictor for chronic neck/shoulder pain in the working population. In the study from Moloney et al. (2018), disability and stress were baseline predictors for higher pain levels in CNP; and in the study from Svedmark et al. (2018), where almost 70% of the sample size was constituted by office workers, higher perceived stress was associated with higher neck pain and disability.

A causal relationship between work-related stress and disorders in the upper limb and neck was also demonstrated in general workers (Bongers et al., 2006; Larsson et al., 2007). In office workers, stress is a work-related risk factor for neck pain, caused by “high job strain” (Hannan et al., 2005; Hagberg et al., 2007; Harcombe et al., 2010), or “high job demands” (Hagberg et al., 2007; Eltayeb et al., 2009; Sihawong et al., 2016). Stress is also being linked with the sensation of muscle tension, and “high muscle tension” is a risk factor for neck pain reported by a systematic review and meta-analysis, which only included prospective studies (RR:2.75, CI:1.60-4.72, *p*=0.0002) (Jun et al., 2017).

Subjects with higher levels of stress and anxiety also have sleep disturbances (Kim & Dimsdale, 2007; Nijs et al., 2018). General workers with moderate to severe sleep problems were associated with a risk of 1.16 to 1.89 times more to work disability due to musculoskeletal problems (Salo et al., 2010). In a large study base-population, co-morbid pain and insomnia together increased the risk for work disability (Lallukka et al., 2014). In our study, there was only a correlation between sleep and pain in chronic trapezius myalgia group. Still, there is some evidence that sleep problems precede pain and increases the risk for the development of chronic pain (Finan et al., 2013; Sivertsen et al., 2015).

Moreover, there are some findings that stress and sleep contribute to sensitization. Higher levels of stress were associated with widespread hyperalgesia with lower PPT in the upper trapezius, in the supraspinatus, and in the tibia, both in men and women (Hven et al., 2017). In a large population-based study, sleep impairment was associated with increased pain sensitivity (Sivertsen et al., 2015). Curatolo et al. (2015) also found that pain-related with sleep interference was associated with pain hypersensitivity. From healthy subjects, sleep disturbance significantly impaired CPM (Smith et al., 2007; Finan et al., 2013; Staffe et al., 2019), increased pain sensitivity (Schuh-Hofer et al., 2013; Staffe et al., 2019) and facilitated TSP (Staffe et al., 2019). The negative correlation of all PPT's points in the chronic trapezius myalgia group and moderate pain group with disability, the positive correlation between sleep and stress with pain intensity in chronic trapezius myalgia group, and the association of stress with disability might explain the widespread hyperalgesia verified in these groups.

6.4.3 Clinical Implications

An office worker with CNP, without a clear pathoanatomical cause (Blanpied et al., 2017), reporting a moderate pain intensity, can be indicative of a central facilitation of the repeated nociceptive input. In the clinical practice, this can be more important than to differentiate between chronic non-specific neck pain and chronic trapezius myalgia. Further pain mechanism assessment is required, and pressure pain threshold and temporal summation of pain are possible clinic tests. Inquiring about disability, stress and sleep patterns are essential clinical keys features to be addressed. Strategies to improve these outcomes should be implemented in pain management (Pelletier et al., 2015; Chimenti et al., 2018).

6.4.4 Limitations

A higher number of male subjects were found in the asymptomatic group compared with the symptomatic groups in the current study. Although the statistical analysis was conducted to minimize the gender effect, it is well known that females have a greater risk of chronic pain and that several QST parameters are different comparing females and males (Rolke et al., 2006; Bulls et al., 2015, Frey-Law et al., 2016). Also, the principal investigator who was not blinded to group allocation. Therefore, the results of the current studies should be interpreted with care.

6.4.5 Conclusion

Office workers with chronic trapezius myalgia and moderate pain intensity show signs of sensitization demonstrated by widespread pressure hyperalgesia in distal segmental areas. Moreover, office workers with moderate pain intensity showed facilitated temporal summation when compared with mild intensity and asymptomatic groups. This could be indicative of a central facilitation of the repeated nociceptive input.

Temporal summation of pain and disability were independently associated with pain intensity in pain conditions groups, and stress and sleep were independently associated with disability. Quantitative sensory testing and psychosocial factors, mainly sleep and stress, provide insight into the fundamental aspects of chronic neck pain in office workers with pain.

6.5 Reference List

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7

Upper and lower trapezius muscle strength in female office workers with chronic neck pain[4]

[4] Nunes, A., Miguel, J., Espanha, M., Arendt-Nielsen, L., Petersen, K. (2020). Upper and lower trapezius muscle strength in female office workers with chronic neck pain. Journal of Manipulative and Physiological Therapeutics (under review).

7.1 Introduction

The prevalence of chronic neck pain (CNP) in office workers ranged between 20 to 60% (Janwantanakul et al., 2008; Cunha-Miranda et al., 2010; Madeleine et al., 2013; Sarquis et al., 2016). In a recent systematic review, self-perceived high muscular tension as an individual risk factor for developing neck pain in office workers (Jun et al. 2017). The trapezius muscle is highly active during computer work (Voerman et al., 2007; Johnston et al., 2008a; Sjøgaard et al., 2010; Wegner et al., 2010; Castelein et al., 2015) and trapezius myalgia is characterized by tightness and tenderness on palpation (Anderssen et al., 2008; Nielsen et el., 2010; Sjøgaard et al., 2010; Jull-Kristensen et al., 2011).

A decreased in maximal voluntary contraction (MVC) in the upper trapezius muscle (UT) have been found in office workers with CNP (Schulte et al., 2006; Sjøgaard et al., 2006; Andersen et al., 2008; Nielsen et al., 2010; Bech et al., 2017) but less is known about the MVC in the middle and lower trapezius (LT).

The trapezius muscle has an important function in avoiding compressive loads on the cervical spine (Johnson et al., 1994), scapula movement and stabilization (Johnson et al. 1994, Cagnie et al., 2014; Camargo & Neumann, 2019). During a computer work task, in asymptomatic subjects, a faster typing speed, increases the electromyography (EMG) activity in UT, decreases in LT, which increases the ratio UT/LT (Huang et al., 2012). A taping technique in UT reduces the ratio UT/LT EMG during typing tasks reflecting a better synergistic relationship in both trapezius muscles (Huang et al., 2012; Takasaki et al., 2015) Experimental UT muscle pain causes a reorganization of the trapezius muscle subdivisions (Falla et al., 2007). In subjects with neck pain compared with healthy subjects, there was some evidence in higher EMG activity in LT during activities such as typing (Castelein et al., 2015). There is a weak association in changes in trapezius muscle activity with cervical posture (Shahidi et al., 2012; Gaffney et al., 2014). However, a scapula postural correction during a typing task causes a similar activity of LT between neck pain and healthy subjects (Wegner et al., 2010). Exercises focusing on LT strengthening and improving UT/LT ratio is essential in a scapula rehabilitation program (Cools et al., 2014).

Therefore, it is necessary to explore the ratio UT/LT (Cools et al. 2014; Camargo et al., 2019) and other factors that cause a decrease in UT and LT MVC in this population (De Meulemeester et al., 2017). Widespread hyperalgesia (Johnston et al., 2008b; Ge et al., 2014) and less efficient descending pain modulation (Shahidi et al., 2015), has been reported in office workers with CNP with severe pain and similar findings have been reported in chronic trapezius myalgia (Leffler et al., 2003; Sjörs et al., 2011). In chapter 6 it was demonstrated widespread pressure hyperalgesia and enhanced temporal summation of pain in office workers with chronic trapezius myalgia and moderate pain intensity compared with healthy controls. Recently, it was demonstrated that eccentric training of UT improved conditioned pain modulation and reduced widespread pain sensitivity in office workers with CNP (Heredia-Rizo et al., 2019).

The current study aimed to investigate MVC in UT and LT in office workers, comparing different conditions and intensities, and to investigate the associations between the ratio UT/LT, pain intensity and pain sensitivity measures (pressure pain threshold and temporal summation of pain) in UT and LT MVC.

7.2 Methods

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethic Council (CEFMH) at the Faculty of Human Kinetics – Lisbon University (Approval Number:23/2017). All participants gave written informed consent.

7.2.1 Participants

A total of 133 office workers with or without pain in the neck region were recruited to participate in the study. The study population was selected as a sub-sample of the 601 CW from Lisbon University, Algarve University, and Albufeira City Council, who participated in a cross-sectional epidemiological study online survey. In this study, data were collected from February 2018 to May 2019. The eligible criteria were adult office workers from 25-60 years of age; working at least for more than one year in the same job position and working at least 3/4 of the working hours on a computer, as used in previous studies (Johnston et al., 2008b; Sjors et al., 2011; Andersen et al., 2014).

The online survey included the Portuguese version of the Standardized Nordic Musculoskeletal Questionnaire (Mesquita et al., 2010). Office workers reporting neck-shoulder trouble (pain, ache, or discomfort) for more than 90 days during the last year were assigned for pain groups. Office workers reporting no neck and upper limb symptoms were assigned to the asymptomatic control group. The exclusion criteria for office workers were: medical history of cardiovascular, cerebrovascular events; major chronic diseases; neurologic diseases; metabolic diseases; pregnancy; rheumatologic diseases; fibromyalgia; whiplash disorders; cervical disc herniation or severe disorders of the cervical spine such severe osteoarthritis; and past neck fractures. For the symptomatic office workers no more than 30 days of pain or discomfort in no more than three out of eight major body regions (neck/shoulder, low back, and left or right arm/hand, hip, knee, foot) to exclude widespread musculoskeletal diseases; signs of tendinitis or joint affection in the shoulders at examination (Søgaard et al., 2012; Gerdle et al., 2014).

A standard clinic examination and group categorization followed the same process described recently in chapter 6. Briefly, the examination was performed, by one examiner with more than 15 years of clinic experience, to ensure that the subjects met the above criteria. This examination included questions about pain duration (to be defined as chronic pain must be present for more than three 3 months) (Smith et al., 2019); pain intensity; pain localization; tiredness and stiffness in the neck and shoulder region on the day of examination; neck and shoulder range of motion (Ohlsson et al., 1994; Kristensen et al., 2006). Office workers were asked to not take any analgesics or nonsteroidal anti-inflammatory drugs (NSAIDs) 24 hours before the examination.

The female study population was divided in CNP and asymptomatic office workers. The office workers with CNP were categorized into pain conditions groups and pain intensity groups, each in two groups. The pain conditions groups were divided in chronic trapezius myalgia, and in chronic non-specific neck pain. The pain intensity groups were based on VAS less or equal 3 into mild pain group and greater than 3 as moderate pain group (Collins et al., 1997; Petersen et al., 2015). The asymptomatic office workers were assigned as a control group.

The diagnosis criteria for trapezius myalgia were: (1) chronic neck pain mainly in upper trapezius muscle; (2) tightness of the trapezius muscle (i.e., a feeling of stiffness in the descending region of the trapezius muscle was reported by the subject at examination of lateral flexion of the head); (3) tenderness on palpation in the UT; (4) cervical spine was to have non-painful, normal or only slightly decreased range of motion (Nielsen et al., 2010; Sjøgaard et al., 2010; Jull-Kristensen et al., 2011). The examination protocol allowed the examiner to identify and exclude the subjects with pain in the trapezius region that was most likely referred from painful tendons or nerve compressions in the neck and shoulder area (Anderssen et al., 2008, Nielsen et el., 2010; Sjøgaard et al., 2010; Jull-Kristensen et al., 2011). If there was a decrease in neck range of motion, pain during neck movement, or pain not specific in upper trapezius, the condition was considered to be non-specific chronic neck pain. Office workers were considered to be asymptomatic based on VAS score (VAS=0) in the neck and upper limb (Ge et al. 2014), no more than three body regions with more than 30 days of trouble or pain on the online survey and in the clinic examination (Nielsen et al., 2010; Søgaard et al., 2012).

7.2.2 Demographics

Demographic variables included were age, BMI, working hours with a computer per week, working hours with computer per day, number of years working with computers, physical activities involving upper limb (average and number of hours per week), pain intensity, pain duration, analgesics or NSAIDs taking from more than 24 hours for the neck pain, and current treatment for neck pain.

7.2.3 Pain Intensity

During the last seven days and in the assessment day, the pain intensity was assessed on a Visual Analog Scale (VAS), anchored at 0: no pain and 10: worst pain imaginable

7.2.4 Quantitative Sensory Testing

7.2.4.1 Pressure Pain Threshold

Pressure pain thresholds were assessed using a hand-held pressure algometer consisted of a 1 cm^2 rubber tip applicator, placed perpendicularly to the skin, mounted on a force transducer at an application rate of 1.0 kgF/s (JTech Medical, Salt Lake City, USA). PPT was defined as the minimum pressure first evoking a sensation of pain. An upper cut-off limit of 500 kPa was used. Pressure pain thresholds were measured twice with an interval of 10 seconds for each point, and the mean value was used for statistical analysis, as previously described (Balaguier et al., 2016).

Four different assessment sites were used: upper trapezius in the most painful side/dominant side and the same point in the contralateral muscle, extensor carpi ulnaris and tibial anterior. The upper trapezius point was localized in the midpoint between C7 and acromion, (Ge et al., 2014); the extensor carpi ulnaris muscle belly point was localized from the lateral epicondyle that was the reference point: 40 mm inferior in a vertical line and then 20 mm posterior (Fernández-Carnero et al., 2010; Ge et al., 2014); the tibialis anterior point was defined approximately 2.5 cm lateral and 5 cm inferior to the tibial tubercle (Walton et al., 2011). The extensor carpi ulnaris and tibialis anterior points were on the same side as the most painful side/dominant side in upper trapezius. The upper trapezius measurement was in a prone position, and the other two points were in the supine position. Each point was marked by a pen marker.

7.2.4.2 Temporal summation of pain

A modified von Frey stimulator (Aalborg University, Aalborg, Denmark) with a weighted load of 25.6 g was used to induce temporal summation of pain. The procedure consisted of the application on ten consecutive stimulations with a 1-second interval between stimulations, in the upper trapezius on the most painful side/dominant side in the same point previously described with the subjects in a sitting position. Each subject was asked to rate the pain intensity from the first and last stimulus on the VAS. Temporal summation of pain was calculated as the difference in pain intensity between the first and the last stimuli, as previously described (Kurien et al., 2018; Petersen et al., 2015, 2018).

7.2.5 Upper Trapezius and Lower Trapezius MVC

A hand-held dynamometer (Lafayette Manuel Muscle Test System Model 01163, Lafayette Instrument Co., NL, USA) was used to measure the strength of UT and LT. The scapula was placed in a neutral position to achieve an optimize length-tension relationship of the muscle being test to produce an MVC. This neutral position was estimated at the midpoint of the full scapula range of motion (Cools et al., 2014; Struyf et al. 2014). The best positions tests for UT and LT MVC were previously determined by Ekstrom et al. (2005). For UT MVC, the subject was in sitting position with their feet flat on the floor, and the hand-held dynamometer was placed over the superior part of the acromion while the patient performed a shoulder-shrugging action (Michener et al., 2005). For LT MVC, the subject was in the prone position with the arm in 145º of abduction with the thumb pointing up (external rotation). The degree of abduction was determined by placing a goniometer along the lateral border of the scapula aligned with the humerus head axis. The hand-held dynamometer was placed on the distal radial styloid process, to apply a downward force while the subject raised the arm (Donatelli et al., 2000; Michener et al., 2005; Petersen et al., 2016).

In the assessments, the examiner was placed laterally in relation to the office workers, on the same side being tested. Those positions allowed the examiner to hold the hand-held dynamometer in order to apply a force in the desired direction. Each office worker performed three MVC with a minimum of 60s rest between each repetition, and the average from the three repetitions was used for data analysis (Michener et al., 2005; Celik et al., 2012; Day et al., 2015; Ha et al., 2016; Petersen et al., 2016; Hannah et al., 2017; Vannebo et al., 2018).

A "make test" procedure was used for all measurements to determine UT and LT MVC. Each office worker received the instruction, after the first hand-held dynamometer beep, to slowly and progressively produce muscle contraction for the first 2 seconds and to reach maximum strength until the 5 seconds, and to stop completely after the second hand-held dynamometer beep (Hayes et al., 2002).

7.2.6 Intra and Inter-rater Reliability

A pilot study was conducted to assess intra and inter-rater reliability in using hand-held dynamometer. Ten office workers (4 males and 6 females) with a mean age 33.6±12.66, weight 61.65±5.96 kg, and height 167.95±8.24 cm^2. All the office workers had a disability score less than 10% of the maximum score measured by the Quick version of the Disability of the Arm, Shoulder, and Hand (QuickDASH) Questionnaire translated and validated to the Portuguese language (Santos & Gonçalves, 2005).

The intra and inter test-retest was conducted in two different days with an interval of 72 hours, and each rater (A and B) assessed UT and LT muscle strength in all office workers in days one and two. The inter-rater reliability was greater for UT (mean ICC:0.93, 95%CI: 0.73, 0.98), and substantial reproducibility for LT (mean ICC:0.86, 95%CI: 0.52, 0.97). The intra-rater reliability for rater A was substantial for UT (mean ICC:0.89, 95%CI: 0.61, 0.97) and greater reproducibility for LT (mean ICC:0.90, 95%CI: 0.66, 0.97). For rater B was substantial reproducibility for UT (mean ICC:0.88, 95%CI: 0.59, 0.97) and LT (mean ICC:0.86, 95%CI: 0.53, 0.96). These results were similar to previous studies (Michener et al. 2005, Day et al. 2015, Petersen et al., 2016). The ICC was interpreted as follows: less than 0.40 – low reproducibility; between 0.40 and 0.75 – moderate reproducibility; between 0.75 and 0.90 – substantial reproducibility, and greater than 0.90 – excellent reproducibility (Maher et al., 2007).

7.2.7 Experimental protocol

All the quantitative sensory measurements were performed by the principal investigator who was not blinded to group allocation. The UT and LT MVC measurements were performed by a second assessor which was blinded to group allocation. A code was introduced for each group for the statistical analyzes assessor remain blinded to group allocation. After the clinic examination the sequence of the quantitative sensory procedures were: 1) PPT measured in the upper trapezius in the most painful side/dominant, the same point in the contralateral muscle, in the extensor carpi ulnaris and in the tibialis anterior (ipsilateral); 2) TSP measurement. There was a five-minute interval between PPT and TSP. The last measurement was UT and LT MVC with a five-minute interval from the quantitative sensory procedures.

7.2.8 Statistics

Descriptive statistics were calculated for age, height, weight, number of working hours per week, number of working hours on the computer, number of years working on the computer, physical activities involving upper limb (average and number of hours per week). The Shapiro-Wilk test was used to test the normal distribution of the variables. Unpaired *t*-tests was used to compare differences between the symptomatic female groups for pain intensity, pain duration, analgesics or nonsteroidal anti-inflammatory drugs (NSAIDs) taking from more than 24 hours, and current treatment for the neck pain.

A one-way analysis of variance (ANOVA) was used to detect the differences between groups in pressure pain threshold and temporal summation of pain. A one-way analysis of covariance (ANCOVA), with age and pain intensity at present-day as covariates, was used to detect the differences in UT and LT MVC with a Bonferroni correction post hoc tests for statistical significance ($p<0.05$. The hand-held dynamometer strength values in Newton (N) were normalized to body weight (recalculated to Newton), which was the most effective anthropometric parameter for normalizing strength values in the upper limb (Hurd et al., 2011; Hannah et al., 2017).

Univariate regression analyses were conducted to investigate the relationship between the dependent variables (UT and LT MVC) and independent variables (pain intensity, pain duration, ratio UT/LT, UT PPT, ECU PPT, TA PPT, and TSP). A stepwise backwards multiple linear regression analysis was conduct with the significant independent variables results from the univariate analyses. The statistical analysis was conducted using SPSS 25.0 software (SPSS Inc., Chicago, IL, USA). Statistical significance was set to $p<0.05$.

7.3 Results

7.3.1 Office Workers Demographics

One hundred and thirty-three female office workers (age 44.3±7.8, weight 63.8±10.3 kg, height 162.77±5.8 cm) were enrolled from the Albufeira City Council (56.4%), from the Lisbon University (30.8%), and from Algarve University (12.8%) in Portugal. The office workers with CNP were categorized into subjects with chronic trapezius myalgia (n=49) and chronic non-specific neck pain (n=46); and into mild pain (n=52) and moderate pain (n= 43) (flow-chart in fig 7.1). Asymptomatic subjects were classified as controls (n=38). See table 7.1 and 7.2 for demographic information.

The chronic trapezius myalgia group had a higher analgesic consumption (p=0.031) and higher clinical pain intensity at present day (*p*=0.027) compared with chronic non-specific neck pain group (table 7.1). The moderate pain group had fewer workers performing current treatment for neck pain (*p*=0.010) and higher clinical pain intensity at present day (*p*<0.0001), compared with mild pain group (table 7.2).

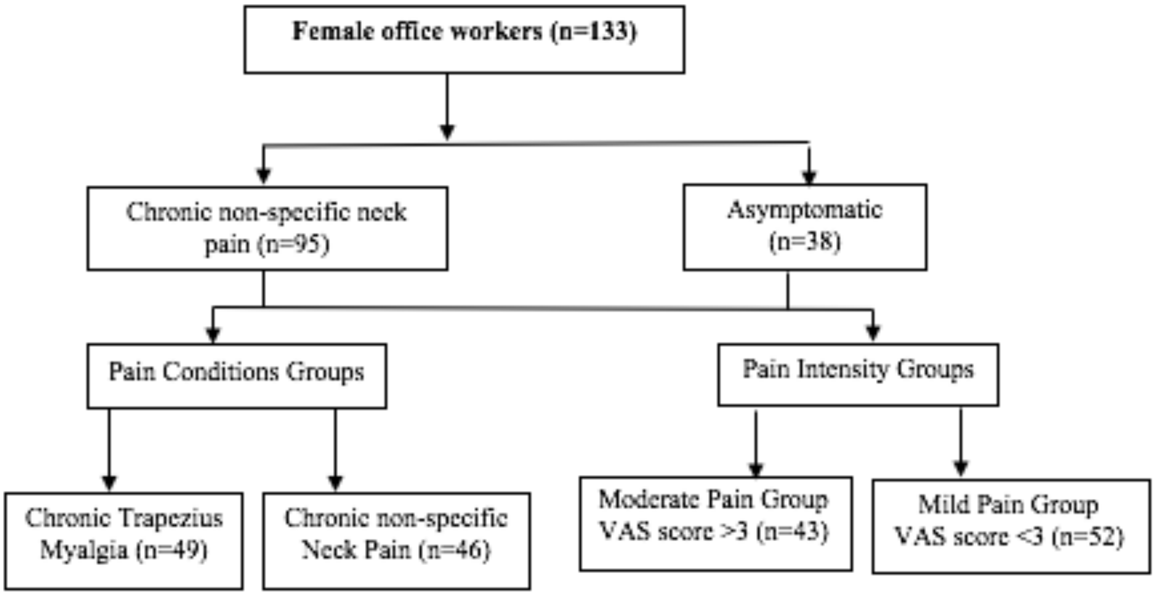

Fig. 7.1 - Flowchart diagram of female office workers

Table 7.1 - Descriptive demographic, quantitative sensory testing and self-reported outcomes of female office workers in pain condition groups

Variable	**Chronic trapezius myalgia (n=49)**	**Chronic non-specific neck pain (n=46)**	**Controls (n=38)**	***P***
Age (years)	42.5 ± 7.2	45.6 ± 7.9	45.0 ± 8.3	.135
Weight (kg)	64.4 ± 10.5	63.7 ± 9.5	65.8 ± 11.0	.269
Height (cm)	161.7 ±5.0	162.4 ± 5.7	164.5 ± 6.4	.066
Working hours (/week)	36.5 ± 4.2	37.1 ± 8.0	38.5 ± 5.7	.322
Working hours on Computer (/day)	6.4 ± 1.0	6.1 ± 1.0	6.4 ± 1.3	.275

Variable	**Chronic trapezius myalgia (n=49)**	**Chronic non-specific neck pain (n=46)**	**Controls (n=38)**	***P***
Nº years working with computer	15.9 ± 7.6	17.8 ± 9.1	18.5 ± 8.5	.321
Physical Activities (UL) *n* (%) yes/no	20 (40.8%) / 29 (59.2%)	21 (46.6%) / 25 (53.3%)	19 (50.0%) / 19 (50.0%)	.692
Physical Activity (h/week)	1.44±1.7	2.21± 2.1	1.98± 2.2	.172
VAS (present day)	2.3 ± 1.9	1.5 ± 1.7	NA	**.027**[a]
VAS (last 7 days)	3.2 ± 1.7	2.7 ± 1.8	NA	.106
Pain duration (months)	76.8 ± 63.4	91.2 ± 65.9	NA	.281
Analgesic + 24 hours *n* (%) yes/no	14 (28.5%) / 35 (71.5%)	5 (10.9%) / 41 (89.1%)	NA	**.031**[a]
Treatment *n* (%) yes/no	5 (10.2%) / 44 (89.8%)	6 (15.0%) / 40 (85.0%)	NA	.666
Quantitative Sensory testing				
PPT UT (dominant side) (kPa)	1.03 ± 0.47	1.28 ± 0.51	1.82 ± 0.91	**<0.001**[b,c]
PPT UT (contralateral) (kPa)	1.04 ± 0.41	1.28 ± 0.55	1.61 ± 0.82	**<0.001**[b,c]
PPT ECU (kPa)	1.21 ± 0.60	1.40 ± 0.48	1.62 ± 0.79	**0.031**[b]
PPT TA (kPa)	3.02 ± 1.06	2.96 ± 1.10	3.16 ± 1.32	> 0.05
Temporal Summation of Pain	1.92 ± 1.66	2.43 ± 2.07	1.59 ± 1.81	.112

Data are expressed as mean ± SD of the mean, or in percentage frequencies (%).

Bold indicates significant (p<0.05).

[a] Between Chronic trapezius myalgia with chronic non-specific neck pain.

[b] Between chronic trapezius myalgia with controls.

[c] Between chronic non-specific neck pain with controls.

Abbreviations: NA, not available; PPT ECU, pressure pain threshold in extensor carpi ulnaris; PPT UT, pressure pain threshold in upper trapezius; PPT TA, pressure pain threshold in tibialis anterior; VAS, visual analogue scale; UL, upper limb.

Table 7.2 - Descriptive demographic, quantitative sensory testing and self-reported outcomes of female office workers in pain intensity groups

Variable	**Mild pain (n=52)**	**Moderate pain (n=43)**	**Controls (n=38)**	***P***
Age (years)	43.8 ± 7.8	44.2 ± 7.6	45.0 ± 8.3	.755
Weight (kg)	62.6 ± 10.2	63.5 ± 9.8	65.8 ± 11.0	.272
Height (cm)	161.6 ± 5.0	162.7 ±5.8	164.5 ± 6.4	.058
Working hours (/week)	38.1 ± 6.3	35.8 ± 4.3	38.5 ± 5.7	.084
Working hours on Computer (/day)	6.4 ± 1.0	6.1 ± 1.1	6.47 ± 1.3	.442
Nº years working with computer	17.5 ± 8.1	16.0 ± 8.6	18.5 ± 8.5	.367
Variable	**Mild pain (n=52)**	**Moderate pain (n=43)**	**Controls (n=38)**	***P***
Physical Activities (UL) *n* (%) yes/no	27 (51.9%)/ 25 (48.1%)	15 (34.9%) / 28 (65.1%)	19 (50.0%) / 19 (50.0%)	.210
Physical Activity (h/week)	2.11± 1.9	1.5±1.9	1.98± 2.20	.355
VAS (present day)	1.21 ± 1.1	2.8 ± 2.1	NA	**<0.001[a]**
VAS (last 7 days)	1.57 ± 0.9	4.68 ± 0.96	NA	**<0.001[a]**
Pain duration (months)	91.21 ± 65.9	76.8 ± 63.4	NA	.281
Analgesic + 24 hours *n* (%) yes/no	8 (15.4%) / 44 (84.6%)	12 (27.9%) / 31 (72.1%)	NA	.135
Treatment *n* (%) yes/no	10 (19.2%) / 42 (80.8%)	1 (2.3%) / 42 (97.7%)	NA	**.010[a]**
Quantitative Sensory testing				
PPT UT (dominant side) (kPa)	1.19 ± 0.52	1.10 ± 0.48	1.82 ± 0.91	**<0.001[b,c]**
PPT UT (contralateral) (kPa)	1.16 ± 0.45	1.15 ± 0.55	1.61 ± 0.82	**<0.001[b,c]**
PPT ECU (kPa)	1.35 ± 0.52	1.24 ± 0.59	1.62 ± 0.79	**0.002[b]**
PPT TA (kPa)	3.15 ± 1.10	2.80 ± 1.09	3.16 ± 1.32	> 0.05
Temporal Summation of Pain	1.45 ± 1.36	3.02 ± 2.07	1.59 ± 1.81	**<0.005[d]**

Data are expressed as mean ± SD of the mean, or in percentage frequencies (%).

Bold indicates significant (p<0.05).

[a] Between moderate pain with mild pain.

[b] Between moderate pain with controls.

[c] Between mild pain with controls.

[d] Between moderate pain with mild pain and controls.

Abbreviations: NA, not available; PPT ECU, pressure pain threshold in extensor carpi ulnaris; PPT UT, pressure pain threshold in upper trapezius; PPT TA, pressure pain threshold in tibialis anterior; VAS, visual analogue scale; UL, upper limb.

7.3.2 Upper Trapezius and Lower Trapezius MVC

In the pain condition analysis, significant lower UT MVC [F (2,128)= 4.099, p =0.019], and lower LT MVC [F (2,128)= 3.511, p =0.033] were found. Post hoc analysis showed lower UT and LT MVC in chronic trapezius myalgia group compared with the control group (p=.025 and p=.029, respectively) (Fig. 7.2A).

In the pain intensity analysis, significant lower UT MVC [F (2,128)= 5.507, p =0.005], and lower LT MVC [F (2,128)= 4.119, p =.018] were found. Post hoc analysis showed lower UT and LT MVC in moderate pain group comparing with controls group (p=0.004 and p=0.014, respectively) (Fig. 7.2B). (Appendix XIII includes UT and LT MVC in male office workers).

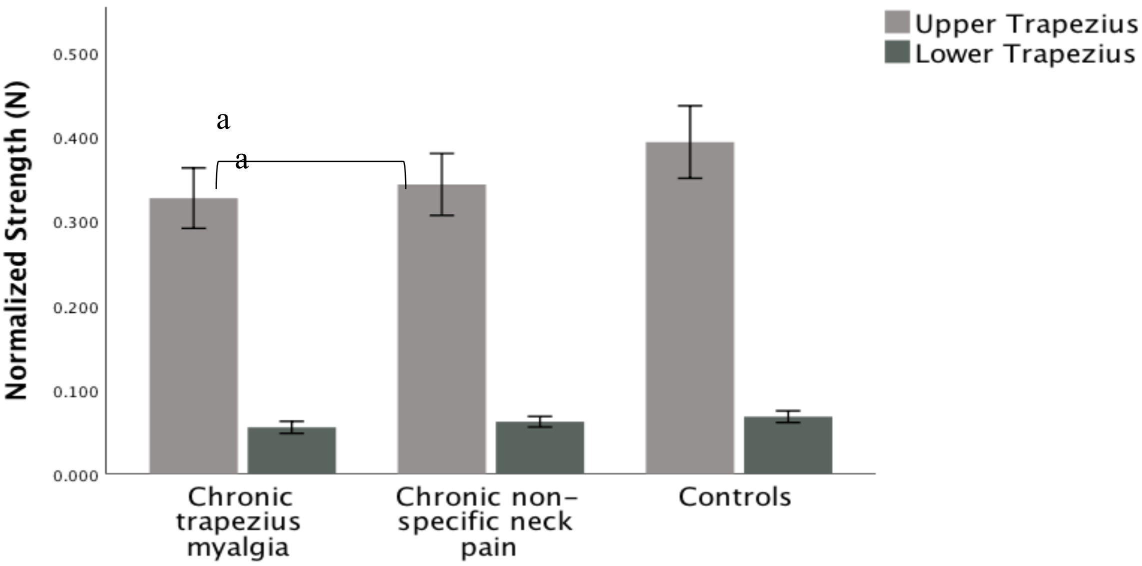

Figure 7.2A – Female office workers strength between pain conditions.

[a] between chronic trapezius myalgia group with controls group, ANCOVA Bonforroni with covariables age and pain day; UT (p =0.025); LT (p =0.029).

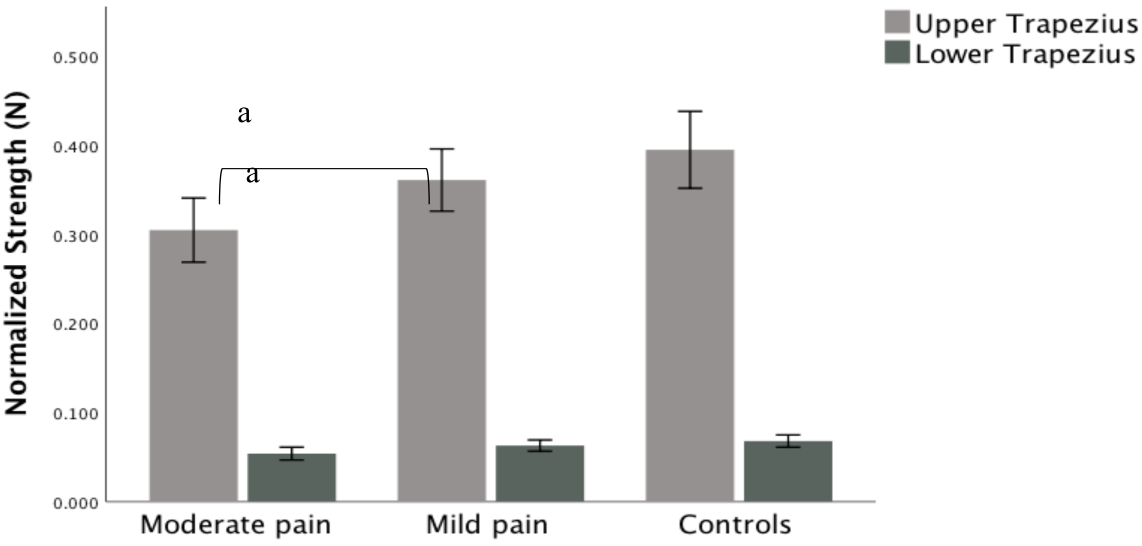

Figure 7.2 B – Female office workers strength between pain intensity; [a] between moderate pain group with controls group, ANCOVA Bonforroni with covariables age and pain day; UT (*p* =0.004); LT (*p* =0.014)

7.3.3 UL/LT Ratio

No statistical difference was found comparing the pain condition groups ([F (2,130)=0.893, p=0.412]), and the pain intensity groups [F (2,130)=0.025, p=0.975].

7.3.4 Time to Peak

No statistical difference were found comparing time to peak in UT ([F (2,130)=1.130, p=0.326]), and in LT [F (2,130)=2.099, p=0.127] in the pain condition analysis (table 7.3).

Table 7.3 – Ratio UT/LT and Time to Peak in pain condition groups.

Variable	Chronic trapezius myalgia (n=49)		Chronic non-specific neck pain (n=46)		Controls (n=38)		Test Statistic
	M (SD)	95% CI	M (SD)	95% CI	M (SD)	95% CI	
Ratio UT/LT	6.28 (1.70)	[5.80,6.77]	5.80 (1.93)	[5.23,6.38]	5.97 (1.68)	[5.41, 6.52]	*F=.893*
Time Peak UT (s)	4.12 (.69)	[3.92, 4.32]	4.27 (.50)	[4.12, 4.42]	4.28 (.43)	[4.14, 4.42]	*F*=1.130
Time Peak LT (s)	4.38 (.57)	[4.21, 4.54]	4.52 (.58)	[4.40, 4.63]	4.27 (,67)	[4.05, 4.49]	*F*=2.099

Abbreviations: LT, lower trapezius; UT, upper trapezius.

Similar, no statistical difference was found comparing time to peak in UT ([F (2,130)=0.806, p=0.449]), and in LT [F (2,130)=1.439, p=0.241] in the pain intensity analysis (table 7.4).

Table 7.4 – Ratio UT/LT and Time to Peak in pain intensity groups.

Variable	Mild pain (n=52)		Moderate pain (n=43)		Controls (n=38)		Test Statistic
	M (SD)	95% CI	M (SD)	95% CI	M (SD)	95% CI	
Ratio UT/LT	6.03 (1.71)	[5.56, 6.51]	5.96 (1.90)	[5.37, 6.54]	5.97 (1.68)	[5.41, 6.52]	*F*=.025
Time Peak UT (s)	4.14 (.90)	[3.96, 4.32]	4.26 (.56)	[4.09, 4.43]	4.28 (.43)	[4.14, 4.42]	*F*=.806
Time Peak LT (s)	4.42 (.68)	[4.28, 4.56]	4.47 (.50)	[4.32, 4.63]	4.27 (,67)	[4.05, 4.49]	*F*=1.439

Abbreviations: LT, lower trapezius; UT, upper trapezius.

7.3.5 Variables Influencing Upper Trapezius and Lower Trapezius MVC

The significant variables from the univariate analysis for UT MVC (pain intensity in the last seven days, ratio UL/LT, extensor carpi ulnaris pressure and tibialis anterior pressure pain threshold), and for LT MVC (pain intensity in the last seven days, ratio UL/LT), were included in a stepwise backwards multiple linear regression analysis. The UT MVC analysis demonstrated that the ratio UL/LT, tibialis anterior pressure pain threshold and pain intensity in the last seven days were independent parameters, $F(3,129)=11.505$, $p<0.0001$, with an overall adj. $R^2=0.193$. The LT MVC analysis demonstrated that the ratio UL/LT and pain intensity in the last seven days were the independent parameters, $F(2,130)=16.861$, $p<0.0001$, with an overall adj. $R^2=0.194$ (Table 7.5 and 7.6).

Table 7.5 – Results of the Univariate Regression Analysis with the average MVC as the dependent variable

Upper trapezius				**Lower trapezius**			
Predictor Variable	**R**	**R^2**	**Sig.**	**Predictor Variable**	**R**	**R^2**	**Sig.**
Pain Duration (VAS)	.104	.011	.235	Pain Duration	.075	.006	.389
Pain 7 Days (VAS)	.217	.047	.012*	Pain 7 Days	.199	.040	.022*
PPT UT (ipsilateral)	.130	.017	.136	PPT UT (ipsilateral)	.077	.006	.379
PPT UT (contralateral)	.149	.022	.088	PPT UT (contralateral)	.089	.008	.309
PPT ECU	.214	.046	.013*	PPT ECU	.091	.008	.296
PPT TA	.263	.069	.002**	PPT TA	.146	.021	.093
TSP	.023	.001	.796	TSP	.026	.001	.774
Ratio UT/LT	.296	.088	.001**	Ratio UT/LT	.413	.171	.001**

*p<.05; ** p<.01; *** p<.001

Abbreviations: PPT ECU, pressure pain threshold in extensor carpi ulnaris; PPT UT, pressure pain threshold in upper trapezius; PPT TA, pressure pain threshold in tibialis anterior; TSP, temporal summation of pain; VAS – Visual analog scale.

Table 7.6 – Multiple Linear Stepwise Regressions with the Average MVC of UT and LT as the dependent variable and the combination of the significant variables identified from the univariate regression analyses

Upper trapezius				**Lower trapezius**			
	R^2	**Adjusted R^2**			**R^2**	**Adjusted R^2**	
Overall model	.211	.193		**Overall Model**	.206	.194	
	β	**SE**	**Sig.**		**β**	**SE**	**Sig.**
Ratio UT/LT	.261	.006	.001***	Ratio UT/LT	-.408	.001	.001***
Pain Intensity	-.279	.001	.001***	Pain Intensity	-.188	.001	.018*
PPT TA	-.278	.009	.001***				

*p<.05; ** p<.01; *** p<.001Abbreviations: PPT TA, pressure pain threshold in tibialis anterior.

7.4 Discussion

The present study found lower UT and LT MVC in female office workers with chronic trapezius myalgia and moderate pain intensity when compared to asymptomatic office workers. The variance in UT and LT MVC was associated with pain intensity in last seven days, the UL/LT ratio in both muscles, and tibialis anterior pressure pain threshold for MVC in UT.

7.4.1 UT and LT strength

This study demonstrated lower UT and LT MVC in female office workers with chronic trapezius myalgia and moderate pain intensity when compared with asymptomatic office workers. The current results from UT are similar with previous studies in office workers with neck pain (Schulte et al., 2006; Sjøgaard et al., 2006; Andersen et al., 2008; Nielsen et al., 2010), and in office workers with chronic trapezius myalgia (Sjøgaard et al., 2006; Andersen et al., 2008; Nielsen et al., 2010).

To our knowledge, this was the first study to report the LT MVC in office workers with chronic neck pain. Our results were in accordance with previous studies, with the same protocol, measured in different populations with chronic unilateral neck pain (Petersen & Wyatt, 2011; Petersen et al., 2016). There is also evidence for reducing neck flexion, extension, and side-bending strength in CNP compared with healthy subjects (Miranda et al., 2019). Therefore, these data provide the rationale for rehabilitation interventions with strengthening exercises programs targeting, at least, neck and upper quadrant muscles, which might be optimized for specific office workers and which is likely to improve pain and muscle strength (Sterling et al., 2019).

Concerning the ratio between UT and LT there were no differences between groups in all analyses. The ratio was higher in the chronic trapezius myalgia group, which can explain the deficits in UT and LT MVC compared with the asymptomatic controls. In our study, the ratio was almost the double when compared with the results from healthy individuals with our data (Turner et al., 2009; Day et al., 2015), and with healthy individuals with scapular dyskinesis (Hannah et al., 2017). This might be explained by differences in the assessment protocol. In the mentioned studies, the measurement of LT, the hand-held dynamometer was placed on the posterolateral angle of the acromion, whereas in our study was placed on the distal radial styloid process (Donatelli et al., 2000; Michener et al., 2005; Petersen & Wyatt 2011; Petersen et al., 2016). Further studies are necessary to quantify and analyzed LT MVC and ratio UT/LT in CNP.

7.4.2 Factors influencing UT and LT MVC

Pain intensity, pain duration, pain sensitivity measures (pressure pain threshold and temporal summation of pain), and the ratio UT/LT were the independent variables to explain the variation in UT and LT MVC. In this study, the ratio UT/LT, pain intensity, and tibialis anterior pressure pain threshold explain 19.3% of the variability in UT MVC, and in LT MVC, the ratio UT/LT and pain intensity explained 19.4%. Our study was the first to analyze the ratio UT/LT affecting trapezius strength. In office workers with CNP, exercises activating more LT and not UT, reduce neck pain, and increases UT MVC (Andersen et al., 2014). The strength rationale for this intervention was based on the knowledge from shoulder disorders and not from neck pain. Moreover, office workers with neck pain increased LT muscle activity measured by EMG compared with healthy controls during typing activities (Castelein et al., 2015), and previously Wagner et al. (2010) demonstrated during typing tasks, correction of scapula position reduce the EMG signal in LT. The findings from our study and the current literature provide a further insight for addressing the ratio of these muscles.

The other important factor was pain intensity. In previous studies, in violinists with CNP, there was an association between pain intensity and lower UT MVC without any association in pain duration (Park et al., 2019). In food services workers with pain in UT, there was an association with LT strength, serratus anterior muscle strength, and Borg rating of perceived extension (Hwang et al., 2017). Also, muscle pain contraction was associated with decreased strength in neck flexion, extension, and lateral flexion in CNP (Lindstroem et al., 2012).

Therefore, there is evidence that pain intensity affects muscle strength. Chronic nociception affects motor output being central mediated with evidence with no changes in the muscle properties (Falla et al., 2007; Graven-Nielsen & Arendt-Nielsen, 2008; Nijs et al., 2012). In experimental muscle pain, it causes an inhibition in the primary motor cortex (Le Pera et al., 2001; Schabrun & Hodges, 2012), with findings that the excitability of the spinal motorneuron remains normal (Schabrun & Hodges, 2012), with a reduce low-threshold motor units fire rate, replaced by the recruitment of new motor units to maintain force (Tucker et al, 2009; Nijs et al., 2012). A systematic review and meta-analysis in chronic pain conditions confirmed a reduction in cortical inhibition from a reduction in short interval intracortical inhibition, and a normal corticospinal excitability (Parker et al., 2016). These results were more consistent in neuropathic pain than in musculoskeletal conditions. In fact, only one study was specific to CNP, which revealed that minor stress causes cortical inhibition when compared with asymptomatic individuals (Marker et al., 2014). Further studies are necessary to quantify those assumptions in CNP.

When the parameter short interval intracortical inhibition is decreased, it can reflect spinal or cortical inhibition and from the systematic review was not possible to conclude the silence period time (Parker et al., 2016). Short interval intracortical inhibition is linked with the activation of GABA mediated inhibitory interneurons, one of the key mechanisms in central sensitization (Parker et al., 2016). In office workers, there are signs of sensitization in those with higher levels of pain intensity (Johnston et al., 2008b; Ge et al., 2014; Nunes et al., in press), and in our study, it explained some of the variability of MVC in UT and LT.

However, it is interesting to analyze the contribution of tibialis anterior pressure pain threshold. Despite there were no significant differences in tibialis anterior pressure pain threshold between groups, it has been proposed that pressure pain threshold values below 246 kPa in tibialis anterior to be considered hypersensitive (Neziri et al., 2011; Waller et al., 2016; Nunes et al., in press), a sign of widespread hyperalgesia (Arendt-Nielsen et al., 2013, 2018). Our results demonstrated that some office workers with moderate pain had those pressure pain thresholds. Moreover, the pressure pain threshold in extensor carpi ulnaris was an independent parameter in univariate regression analysis for UT MVC, and was statistically decreased in chronic trapezius myalgia and moderate pain groups compared with the controls group. In our study, temporal summation of pain was only statistically different in the moderate pain intensity group. The regression analysis was conducted with the overall sample, and this might explain the results. Further studies are necessary to quantify central sensitization affecting muscle strength.

7.4.3 Implications for practice

Female office workers with chronic neck pain, self-reporting a moderate pain intensity demonstrated a significantly lower maximum muscle voluntary contraction in the upper and lower trapezius.

7.4.4 Limitation

The current study utilized a cross-sectional design which does not provide information on causality of the parameters analysis and therefore the study results should be analyzed with care.

7.4.5 Conclusion

Female office workers with moderate pain intensity and with chronic trapezius myalgia demonstrated a significantly lower maximum muscle voluntary contraction in the upper and lower trapezius compared with the other symptomatic groups and controls. There were no statistical differences in the ratio between upper/lower trapezius. Pain intensity and the ratio upper/lower trapezius, explained some of the variability of muscle strength in both muscles, adding pressure pain threshold in tibialis anterior in the upper trapezius.

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8

Bedside clinical tests to assess nociplastic in office workers with chronic neck pain[5]

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8.1 Introduction

Chronic neck pain prevalence in office worker, ranges from 20% to 60% world wid. (Sarquis et al., 2016). Literature suggests that pain chronicity is associated with neuroplastic changes and by having this concept in mind, the identification and classification of the pain related mechanisms as nociceptive, neuropathic or nociplastic, may reveal very useful in designing better pain treatment and management plans (Boudreau et al., 2010; Pavlakovic & Petzke, 2010; Arendt-Nielsen et al., 2011; Pelletier et al., 2015; Chimenti et al., 2018). Furthermore, the term nociplastic pain implies an inference of central sensitization, which can be assessed through quantitative sensory tests (QST) (Kosek et al., 2016).

Pressure pain thresholds (PPTs) are often used parameters in the assessment of musculoskeletal pain conditions (Arendt-Nielsen et al., 2011, 2015a, 2018). When compared with asymptomatic office workers, subjects with chronic trapezius myalgia and moderate pain intensity, exhibit lower pain thresholds, when assessed both on the neck and/or at remote non-painful sites (Nunes et al., 2020), indicating localized and widespread pressure hyperalgesia. Normative cut-off points based on data from healthy subjects have been proposed in the literature (Neziri et al., 2011; Waller et al., 2016).

Widespread pain sensitivity can be attributed to changes in wide-dynamic range neurons in the dorsal horn of the spinal cord (Latremoliere & Woolf, 2009; Pelletier et al., 2015; Arendt-Nielsen et al., 2018), and in the descending pain pathways, which can inhibit or facilitate pain sensation (Heinricher et al., 2009; Pelletier et al., 2015; Arendt-Nielsen et al., 2018). Temporal summation of pain (TSP) is believed to assess the excitability within the dorsal horn in the spinal cord. Also, it is believed that condition pain modulation (CPM) may be used to evaluate the inherent capacity of the endogenous pain modulatory system (Yarnitsky et al., 2010; Arendt-Nielsen et al., 2018). In many chronic pain conditions, TSP is often facilitated, and CPM is often impaired (Arendt-Nielsen et al., 2015b, 2018). A recent study observed a facilitated TSP in office workers with chronic neck pain self-reporting a moderate pain intensity when compared to healthy subjects but with no differences in CPM (Nunes et al., 2020). Moreover, recently a normative data set for TSP and CPM based on data from healthy subjects (Schliessbach et al., 2019).

Studies have argued that there is an association between higher clinical pain intensities and decreased PPTs, facilitated TSP and impaired CPM in patients with musculoskeletal pain (Graven-Nielsen & Arendt-Nielsen., 2010; Arendt-Nielsen et al., 2015b). Recent studies indicate that pain catastrophizing might be associated with both QST findings (Christensen et al., 2020) and clinical pain intensities (Lee et al., 2013) and that those associations need further elaboration.

However, QST is not widely implemented in the clinic practice due to the lack of standardized protocols with establishing normative data do detect deviations from the normal (Arendt-Nielsen et al., 2009; Arendt-Nielsen et al., 2015a; Curatolo et al., 2015; Arendt-Nielsen et al., 2018; Chimenti et al., 2018), the expensive equipment and time-consuming nature of the tests (Rolke et al., 2006; Cruz-Almeida & Fillingim, 2014).

The primary aim of this study was to assess sensitization through simple bedside QST findings in individual office workers with chronic neck pain and to identify pain sensitive subjects based on the previous proposed normative data. The secondary aim was to assess the differences between the number of individual pain sensitive QST findings and clinical pain intensity and pain catastrophizing.

8.2 Methods

This study complies to the tenets of the Declaration of Helsinki and was approved by the Ethic Council (CEFMH) at the Faculty of Human Kinetics – Lisbon University (Approval Number:23/2017). All participants gave written informed consent.

8.2.1 Subjects

A total of 104 office workers with chronic neck pain were recruited to participate in the study. The study population with chronic neck pain was retrieved from a larger sample composed with 171 office workers from Lisbon University, Algarve University, and Albufeira City Council, which have participated in an observational analytic and correlational cross-sectional study. In the present work, data were collected from February 2018 to May 2019. The eligible criteria were adult office workers from 25-60 years of age; working at least for more than one year in the same job position and working at least 3/4 of the working hours on a computer (Sjörs et al., 2011, Andersen et al. 2014). The criteria for chronic neck pain was defined to be present for more than three months (Smith et al., 2019). The exclusion criteria for office workers were: medical history of cardiovascular, cerebrovascular events; major chronic diseases; neurologic diseases; metabolic diseases; pregnancy; rheumatologic diseases; fibromyalgia; whiplash disorders; cervical disc herniation or severe disorders of the cervical spine such severe osteoarthritis and past neck fractures; signs of tendinitis or joint affection in the shoulders at examination; and pregnancy (Søgaard et al, 2012).

A standard clinic examination was performed, by one examiner with more than 15 years of clinic experience, to ensure that the subjects met the above criteria. This examination included questions about pain duration; pain intensity; pain localization; tiredness and stiffness in the neck and shoulder region on the day of examination; neck and shoulder range of motion according to Ohlsson and Kristensen (Ohlsson et al., 1994; Juul-Kristensen et al., 2006). Office workers were asked to not take any analgesics or nonsteroidal anti-inflammatory drugs (NSAIDs) 24 hours before the examination.

8.2.2 Demographics

The emographic variables included were age, gender, BMI, working hours on the computer per week, working hours on the computer per day, number of years working with computers, pain intensity, pain duration, analgesics or NSAIDs taking from more than 24 hours for the neck pain, and current treatment for neck pain.

8.2.3 Sef-Reported Measures

8.2.3.1 Pain Intensity

The pain intensity at present day and the average from the last seven days, were assessed on a Visual Analog Scale (VAS), anchored at 0: no pain and 10: worst pain imaginable.

8.2.3.2 Pain Catastrophizing Scale (PCS)

Pain Catastrophizing Scale (PCS) is a 13-item self-reported measure designed to assess catastrophic thoughts or feelings when experiencing pain. It is composed of three subscales: rumination, magnification and, helplessness; items are rated on a 5-point scale ranging from 0 (not at all) to 4 (all the time), the maximum score is 52 being 30 points considered to be a clinically relevant level of catastrophizing (Sullivan & Bishop, 1995). This questionnaire was translated, adapted, and validated to the Portuguese population with chronic pain, and has revealed a good internal consistency in all subscales: rumination (0.796), magnification (0.789) and helplessness (0.897) (Azevedo et al., 2007).

8.2.4 Quantitative Sensory Testing

8.2.4.1 Pressure Pain Threshold

PPTs were assessed using a hand-held pressure algometer consisted of a 1 cm^2 rubber tip applicator, placed perpendicularly to the skin, mounted on a force transducer at an application rate of 1 kg/seg (JTech Medical, Salt Lake City, USA). PPT was defined as the minimum pressure first evoking a sensation of pain. An upper cut-off limit of 500 kPa was used. PPTs were measured twice with an interval of 10 seconds for each point, and the mean value was used for statistical analysis, as previously described (Balaguier et al., 2016).

Three different assessment sites were used: upper trapezius in the most painful side/dominant side and the same point in the contralateral muscle, and tibialis anterior. The upper trapezius point was localized in the midpoint between C7 and acromion, (Ge et al., 2014); the tibialis anterior point was defined approximately 2.5 cm lateral and 5 cm inferior to the tibial tubercle (Walton et al., 2011). The tibialis anterior point was on the same side as the most painful side/dominant side in upper trapezius. For upper trapezius measurement the office workers were in prone position and for tibialis anterior in supine position. Each PPT localization was marked with a pen marker.

8.2.4.2 Temporal Summation of Pain (TSP)

A modified von Frey stimulator (Aalborg University, Aalborg, Denmark) with a weighted load of 25.6 g was used to induce TSP. The procedure consisted on the application of ten consecutive stimulations with a 1-second interval between stimulations, in the upper trapezius on the most painful side/dominant side in the same point previously described with the subjects in a sitting position. Each subject was asked to rate the pain intensity from the first and last stimulus on the VAS. TSP was calculated as the difference in pain intensity between the first and the last stimuli, as previously described (Kurien et al., 2018; Petersen et al., 2015, 2018).

8.2.4.3 Conditioned Pain Modulation (CPM)

CPM was measured as the difference in PPTs at the upper trapezius before and after the cold pressor test (CPT) (Petersen et al., 2015). Measurements were done with the subject in a sitting position, the contralateral hand of the most painful side/dominant side immersed up to the wrist in a cold water bath maintained at 2-3ºC. The subjects were asked maintain the hand immersed for a maximum time of 2 minutes or to remove the hand when a pain intensity of 7 out of 10 was reached on a 0 (no pain) to 10 (worst imaginable pain) scale. The CPM effect was calculated as the ratio between the test stimulus with and without the conditioning stimulus.

8.2.5 Experimental protocol

The sequence of the quantitative sensory procedures were: 1) PPT measured in the upper trapezius in the most painful side/dominant, the same point in the contralateral muscle, in the extensor carpi ulnaris and in the tibialis anterior (ipsilateral); 2) TSP measurement; 3) CPM assessment. There was a five-minute interval between PPT and TSP and between TSP and CPM.

8.2.6 Statistics

Descriptive statistics were calculated for age, gender, BMI, number of working hours per week, number of working hours on the computer, number of years working on the computer, pain intensity at present day, pain duration, analgesics or nonsteroidal anti-inflammatory drugs (NSAIDs) taking from more than 24 hours, and current treatment for the neck pain. The Shapiro-Wilk test was used to test the normal distribution of the variables.
Office workers were analyzed for pain sensitization using previous published normative value data set with the following criteria: a) PPT points were considered hypersensitivity if values were below 155 kPa (upper trapezius) and 245 kPa (tibialis anterior) (Neziri et al., 2011; Waller et al., 2016). b) facilitated TSP was present if the difference between the first and the last stimulus increased 2 points in VAS (Rabey et al., 2019); c) impaired CPM was considered when the CPM effect was lower than -7.5% (Schliessbach et al., 2019). Widespread pain sensitivity was considered present if all the three PPT values were below the cut-off points.

Office workers were grouped into the following groups based on the number of positive QST findings: no findings (QST0), one positive finding (QST1), and two positive findings (QST2). Differences between groups in pain intensity, PCS and PCS subscales were examined using a one-way analysis of variance (ANOVA) with Tukey HSD post hoc tests for statistical significance ($p<0.05$). A Pearson's chi-squared test was used to determine whether there were a statistically difference between the average of the three QST tests in QST1 and QST2 ($p<0.05$). The statistical analysis was conducted using SPSS 25.0 software (SPSS Inc., Chicago, IL, USA).

8.3 Results

8.3.1 Office Workers Demographics

One-hundred-and-four office workers (age 44.0±7.82; weight 65.5±12.7 kg, height 164.2±8.6 cm) were enrolled from the Albufeira City Council (59.6%), from the Lisbon University (25.0%), and from Algarve University (15.4%). Office workers were divided into three groups accordingly with QST findings: QST0 (n=38), QST1 (n=38), and QST2 (n=28) (flow-chart in fig. 8.1). No significant differences were found in the demographics when comparing the groups (table 8.1).

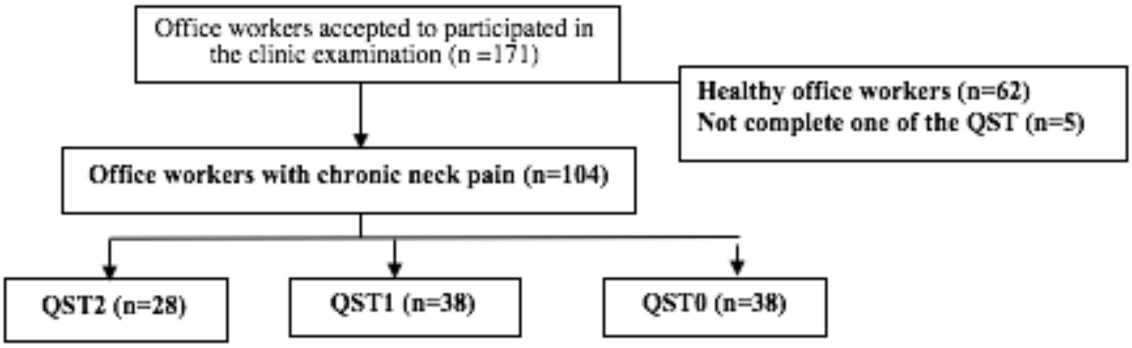


Figure 8.1 – Flowchart diagram of office workers

Table 8.1 - Descriptive characteristics of office workers

Variable	QST0 (n=38)	QST1 (n=38)	QST2 (n=28)	*P*
Age (years)	45.09 ± 8.3	42.86± 7.5	43.4 ± 7.2	.326
Sex, n (%) female/male	35 (87.5%) / 5 (38.7%)	34 (91.9%) / 3 (8.1%)	24 (88.9%) / 3 (11.1%)	.818
Weight (kg)	67.64 ± 13.5	65.09 ± 13.4	63.11 ± 10.3	.330
Height (cm)	164.92 ± 10.2	163.48 ± 7.9	164.29 ± 7.0	.750
Working hours (/week)	35.92 ± 6.33	38.02 ± 7.3	37.92 ± 6.3	.315
Working hours on Computer (/day)	6.31 ± 1.3	6.21 ± 1.0	6.51 ± 1.3	.602
Nº years working with computer	16.55 ± 7.9	16.24 ± 8.6	18.37 ± 7.6	.741

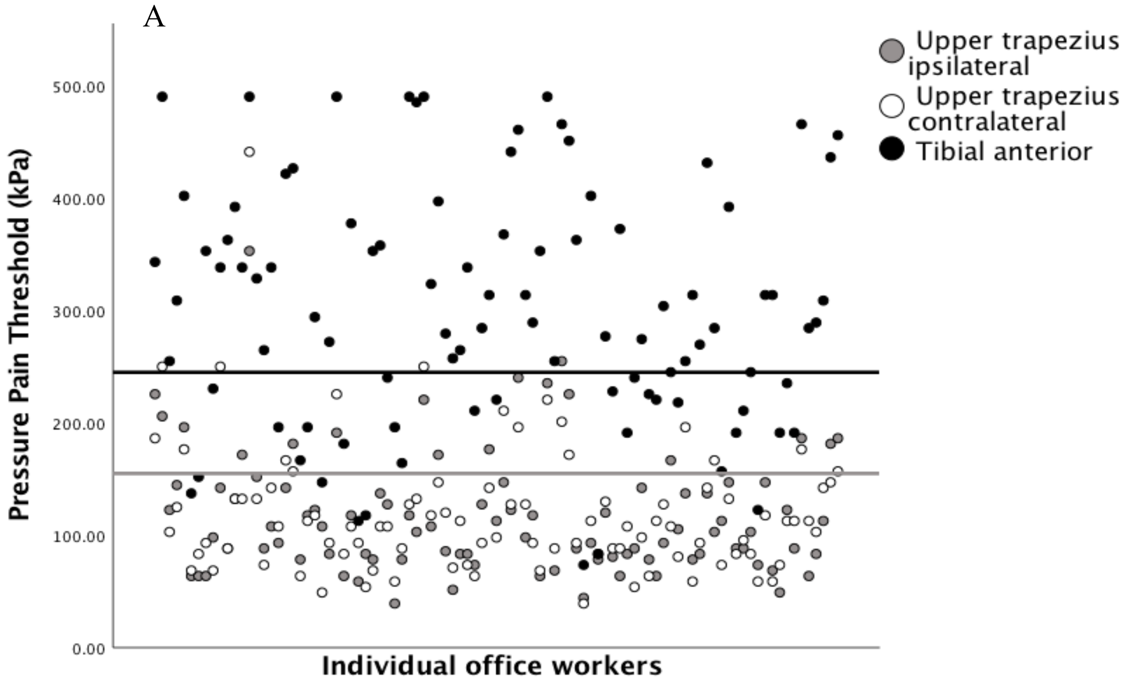
VAS (present day)	1.64±1.51	2.13±1.84	1.97±1.70	.412
Pain duration (months)	85.70 ± 64.5	83.56 ± 57.7	88.66 ± 77.4	.301
Analgesic + 24 hours ***n*** **(%) yes/no**	3 (7.5%) / 37 (92.5%)	10 (27%) / 27 (73%)	5 (18.5%) / 22 (81.5%)	.076
Treatment ***n*** **(%) yes/no**	3 (7.5%) / 37 (92.5%)	4 (18.8%) / 33 (89.2%)	4 (14.8%) / 23 (85.2%)	.633

Abbreviations: VAS – visual analog scale

8.3.2 Quantitative Sensory Testing Findings.

In total 38 office workers (36.5%) had none QST finding and 66 (63.5%) had at least one QST finding. From positive QST findings, 33 office workers (31.7%) demonstrated widespread pressure hyperalgesia (figure 8.2a), 50 office workers (48.1%) demonstrated facilitated TSP (figure 8.2b), and 21 office workers (20.2%) demonstrated an impaired CPM (figure 8.2c) based on the previous published normative values.

A



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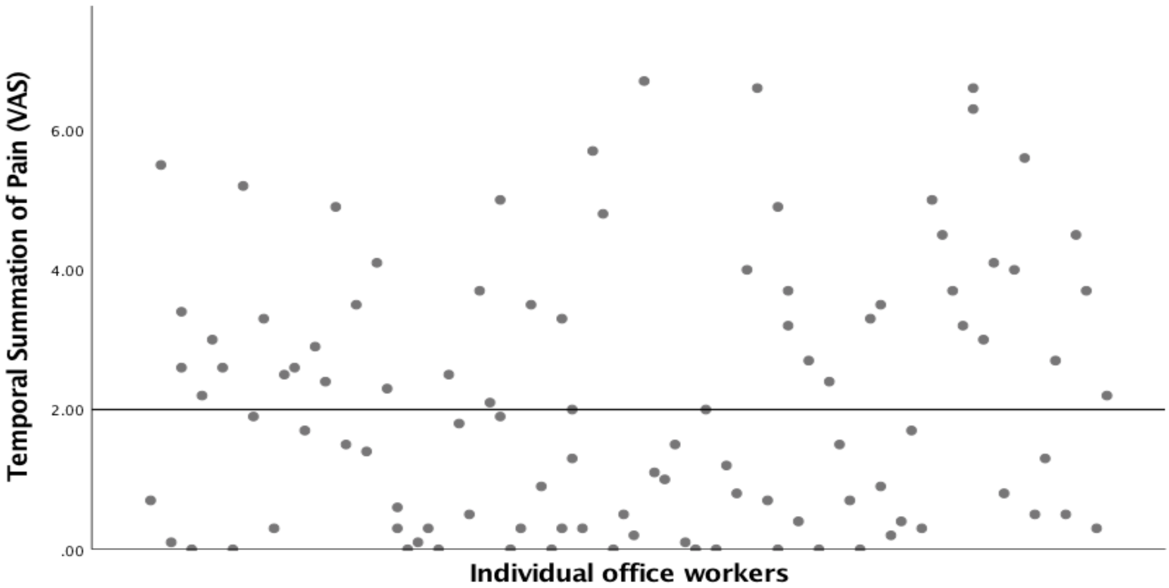

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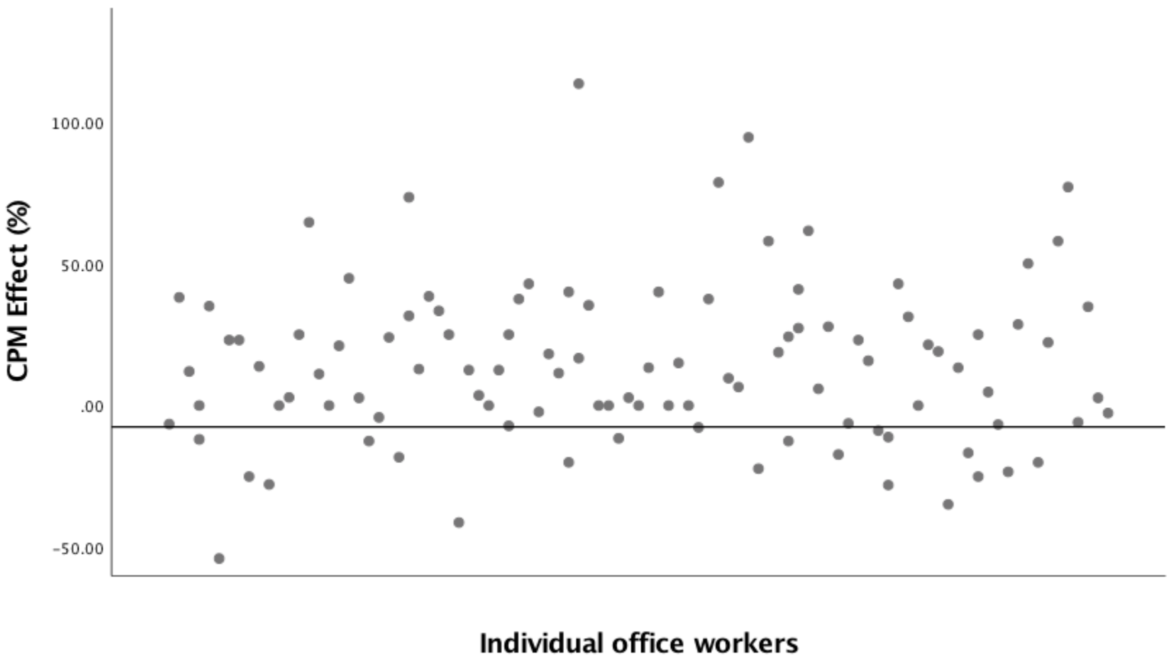

Figure 8.2 – A) Pressure pain threshold (kPa) in all office workers.
Grey line indicates hypersensitivity values below 155 kPa for both upper trapezius points. Black line indicates hypersensitivity values below 245 kPa for tibialis anterior point; B) Temporal summation of pain in all office workers. Values above grey line indicates values higher than 2 in VAS: C) Conditioned pain modulation effect in all office workers. Values below grey line indicates values below -7.5%.

A statistically significant difference in PPTs, TSP and CPM averages between QST1 and QST2, was found in all analyses, $p<0.005$ (table 8.2). In QST2, 10 office workers had all the three QST findings, representing 9.6% of the total sample.

Table 8.2 - Average QST positive tests per group

Variable	QST1 (n=38)	QST2 (n=28)	X^2
	yes/no	yes/no	
PPT	9 (23.7%); 29 (76.3%)	24 (85.7%); 4 (14.3%)	<.0001
TSP	24 (63.2%); 14 (36.8%)	26 (92.8%); 2 (7.2%)	.005
CPM	5 (13.2%); 33 (86.8%)	16 (57.1%); 12 (42.9%)	<.0001

Abbreviations: CPM- conditioned pain modulation; PPT- pressure pain threshold; TSP – temporal summation of pain.

8.3.3 Self-Reported Measures

There was a significant difference in pain intensity [F (2,101)=9.865, p <0.001], and Tukey HSD post hoc analysis showed a higher pain intensity in QST2 comparing with QST0 (p<0.001), and in QST1 comparing with QST0 (p=0.011) (fig 8.3).

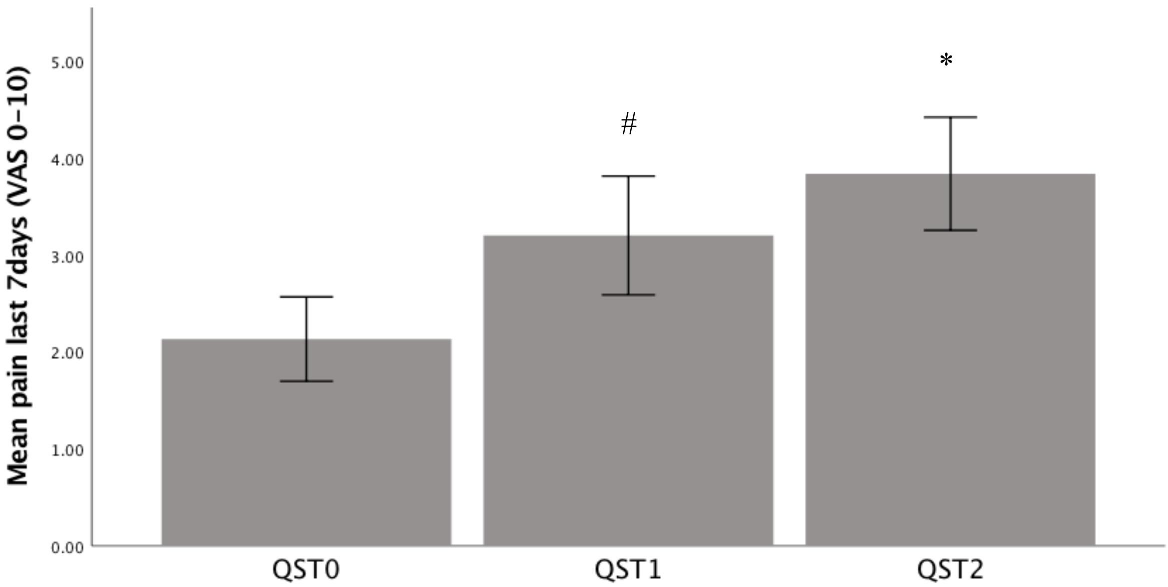

Figure 8.3 – Pain intensity last 7 days per group.
*between QST2 with QST0, Tukey post hoc test p<0.001; # between QST1 with QST0, Tukey post hoc test p=0.011.

There was a significant difference in rumination subscale [F (2,101)=3.060, p =0.05], and Tukey HSD post hoc analysis revealed a higher rumination scores in QST2 comparing with QST0 (*p*=0.047). There were no differences between groups in the other subscales or in the full PCS (table 8.3).

Table 8.3 – Pain catastrophizing scale

Variable	QST0 (n=38)		QST1 (n=38)		QST2 (n=28)		Test Statistic
	M (SD)	95% CI	M (SD)	95% CI	M (SD)	95% CI	
PCS	10.28 (9.44)	[7.18, 13.39]	14.16 (10.57)	(10.68, 17.63]	16.32 (10.65)	[12.18, 20.45]	F= 3.019
Rumination	3.87 (3.84)	[2.52, 5.05]	5.34 (4.23)	(3.94, 6.73]	6.28 (4.48)	[4.54, 8.02] [a]	*F*=3.060
Helplessness	4.15 (3.97)	[2.85, 5.46]	5.42 (4.47)	(3.94, 6.89]	6.50 (4.23)	[4.85, 8.14]	*F*=2.512
Magnification	2.36 (2.48)	[1.55, 3.18]	3.39 (2.71)	(2.50, 4.28]	3.67 (2.69)	[2.63, 4.72]	*F*=2.388

[a] Between QST2 with QST0, Tukey post hoc (*p* =0.047)

Abbreviations: PCS – Pain catastrophizing scale

8.4 Discussion

This study aimed to assess sensitization in office workers with chronic neck pain through simple bedside QST findings and by using an already published normative data set. From the 104 participants, 63.5% exhibited either widespread hyperalgesia, facilitated TSP or impaired CPM. Also, it was found that clinical pain intensity and pain catastrophizing rumination scores increase with an increasing number of positive QST findings.

The present study results are in line with previous studies reporting QST findings in office workers with chronic neck pain (Johnston et al., 2008; Ge et al., 2014; Shahidi et al., 2015; Shahidi & Maluf, 2017; Heredia-Rizo et al., 2019). However, the QST findings in patients with chronic neck pain are still open for debate. As an example, the evidence for widespread hyperalgesia measured by PPT in chronic neck pain in office workers is conflicting. While some studies report no PPT differences (Ge et al., 2014) other studies report widespread pressure hyperalgesia in office workers with chronic neck pain compared with asymptomatic office workers (Johnston et al., 2008; Nielsen et al., 2010; Nunes et al., 2020). Nevertheless, the findings of this study concerning PPT results, were found to be in line with the aforementioned studies and a recent systematic review and meta-analysis from Xie et al. (2020) for neck pain. The systematic review from Xie et al. (2020) found moderate-quality evidence of widespread pressure hyperalgesia in PPTs in the tibialis anterior compared to patients with non-traumatic neck pain with healthy controls. However, the review did not specifically address to office workers and both participants with acute and chronic pain were considered, therefore caution is recommended when extrapolating conclusions out of the results.

The conflicting results concerning QST found across the literature, can also be applied to CPM, where no difference between office workers with chronic neck pain and health workers have been reported (Ge et al., 2014; Heredia-Rizo et al., 2019; Nunes et al., 2020). Nonetheless, in the studies from Shahidi et al. (2015) and Shahidi and Maluf (2017), CPM was considered to be a risk factor for developing chronic interfering neck pain in a twelve-month prospective cohort study with office workers. In the present study, 20% of the population were characterized with impaired CPM, and this could suggest that only a subpopulation of patients might display impairment of descending pain pathways, as seen in other musculoskeletal pain conditions (Petersen et al., 2016; Vægter et al., 2016).

TSP can be elicited by different modalities such as thermal, electric, or pressure (Graven-Nielsen & Arendt-Nielsen, 2010; Arendt-Nielsen et al., 2018). In the study from Heredia-Rizo et al. (2019), TSP was collected by cuff-algometer in the lower limb, with no differences in the same population when compared with health office workers. In a previous study, eliciting TSP by a pinprick in the upper trapezius (painful side/dominant side), there was an enhanced TSP in office workers with moderate pain intensity compared with asymptomatic (Nunes et al., 2020). The TSP test-retest reliability by pinprick demonstrated moderate to good reliability in long term reliability in healthy subjects (Marcuzzi et al., 2017; Nothnagel et al., 2017), with good to excellent reliability in acute musculoskeletal trauma (Middlebrook et al., 2020) and good reliability in neurologic conditions (Geber et al., 2011). The 48.1% of office workers with facilitated TSP found in the present study, suggests that only a subpopulation of patients with chronic neck pain might exhibit facilitated TSP.

Previous studies have reported a correlation between pain intensity with less efficient CPM (Ge et al., 2014) and enhanced TSP (Nunes et al., 2020). Our results revealed that the QST2 and QST1 groups had a significantly higher intensity pain comparing with QST0. Moreover, in the QST2 group, there was an association between pain intensity with the rumination subscale in the Pain Catastrophizing Scale. This result is in accordance with previous studies where an association was verified between pain catastrophizing and higher pain intensity in subjects with CNP (Thompson et al., 2010; Park et al., 2016). Also, in a recent review of systematic reviews of prospective cohort studies, pain catastrophizing was a longitudinal psychological risk factor associated with pain intensity and dysfunction in persistent musculoskeletal pain cases (Martinez-Calderon et al., 2020).

Quantitative Sensory Testing normative values and cut-off points

The current study used normative data and cut-off points to be easy to implement in the clinical practice. For PPT assessment, the reference scores were established based on the ones previously reported in the literature (Neziri et al., 2011; Waller et al., 2016; Nunes et al., 2021), and allowed us to identify the subjects with hypersensitivity PPT values in the upper trapezius and the tibialis anterior. Furthermore, in a non-painful region in subjects with chronic neck pain, these reference values from the tibialis anterior suggested widespread pressure hyperalgesia, a signal of central sensitization (Arendt-Nielsen et al., 2011; 2018).

The cut-off of 2 points in VAS was used for an enhanced TSP (Rabey et al., 2019). Further research will be needed to determine if this is actually the ideal cut-off point regarding the different methods to induced TSP. Nevertheless, this cut-off point was used with a pinprick (Rabey et al., 2019). In clinical practice, the problem of calculating a wind-up ratio comes up when the self-reported pain intensity of the first stimulus by the patient is zero. Typically, another heavier pinprick is used (Marcuzzi et al., 2017). In our study, oftenly the first stimulus did not elicited pain.

With concern to CPM, also variability can be observed, namely between healthy female and male subject (Bulls et al., 2015; Graven-Nielsen et al., 2015; Hermans et al., 2016; Skovberg et al. 2017), and between younger and older ages (Grashorn et al., 2013, Hermans et al., 2016). Therefore, there is a need for reference CPM values to be used in the clinical practice to assess dysfunctional pain modulation. Schliessback et al. (2019) study provided percentiles for CPM with the cold pressor test as the conditioning stimulus for assessing dysfunctional pain modulation. This study used the 5th percentile proposed by the same author as a cut-off point for a normal CPM which is very conservative in identifying dysfunctional pain modulation and a negative CPM value which may not necessarily reflect an abnormal CPM (Schliessback et al., 2019). Nevertheless, an office worker with chronic neck pain, self-reporting a moderate pain intensity plus other QST test findings, can be found to be a consistent result to consider an impaired endogenous pain modulation.

Finally, time-consuming, expensive equipment, multiple QST tests, lack of normative data between symptomatic and asymptomatic populations were identified as potential barriers to implementing QST in the clinical practice (Rolke et al., 2006; Cruz-Almeida & Fillingim, 2014). The present work used standard procedures for assessing signs of sensitization in a chronic musculoskeletal condition (Graven-Nielsen & Arendt-Nielsen, 2010; Petersen et al., 2015; Arendt-Nielsen et al., 2018) with non-expensive equipment (algometer, pinprick, ice, and water), quicker and simple, with normative data and cut-off points which might introduce a more straightforward QST assessment than the ones previously found in the literature.

8.5 Clinical Implications

The current study is the first to use normative reference values and cut-off points from the literature in patients with chronic neck pain, meaning that it is possible to assess sensitization through simple bedside QST findings in clinical practice.

8.6 Limitations

In the current study, it was not possible to measure all the outcomes at the same workweek day for all office workers. Fatigue resulting from working on computer can influence the QST results and therefore it might be considered to be a limitation (Grimby-Ekman et al., 2020).

8.7 Conclusion

This study demonstrated that 63.5% of office workers with chronic neck pain demonstrated either widespread pressure hyperalgesia, facilitated temporal summation of pain or impaired conditioned pain modulation, indicating pain sensitization within the central nervous system. Furthermore, increasing positive signs of central pain sensitization were associated with higher clinical pain intensity and pain catastrophizing rumination scores.

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9

Discussion and conclusion

9.1 Overview

This thesis aimed to assess nociplastic pain in office workers with chronic neck pain through QST, comparing the differences between pain conditions (healthy subjects, chronic trapezius myalgia and chronic non-specific neck pain) and pain intensities (no pain, mild-pain and moderate-pain) (Chapter 6 and 7). To start with, we have assessed the prevalence of neck pain and occupational factors associated with neck pain in Portuguese office workers (Chapter 5). In order to estimate sensitization in individual office workers, it was necessary to analyse QST reference values (Chapter 4 and 8). This project additionally aimed to investigate the associations between pain intensity, disability (Chapter 6), pain catastrophizing (Chapter 6 and 8), psychological factors (Chapter 6), muscle strength (Chapter 7), and pain sensitivity measures (Chapter 6 and 8).

Recognising a nociplastic pain is still a challenge in clinical practice. This research project used simple and affordable QST tools that can be used in a clinic scenario. Furthermore, validated questionnaires in Portuguese were used to have an insight into the multiple psychosocial factors that can contribute to the ongoing pain process. The hallmark of this pain assessment was to deduce the presence of central sensitization so as to decide if the clinical intervention must also include a "top-down" approach (Pelletier et al., 2015; Arendt-Nielsen et al., 2018; Chimenti et al., 2018).

For this purpose, it was necessary to use a systematic review and meta-analysis for assessing the differences in PPT between office workers with CNP and healthy controls (Chapter 4). A second aim was obtaining PPT reference values from office workers with chronic neck pain to recognize widespread pressure hyperalgesia. The systematic review and meta-analysis showed non-significant changes in all PPTs comparing CNP with healthy office workers. The present review provides PPT reference values for upper trapezius and tibialis anterior for office workers with CNP. One of the implications for further research was the small sample sizes between those groups in all the PPT points. This was a major research implication for our third study.

In the second study (Chapter 5), the online questionnaire aimed to identify occupational factors related to neck pain in Portuguese office workers. The main modifiable factors were "the number of working hours on a computer without a break", "screen localization not centred" and "the use of computer mouse more than 50% during worktime", which should be addressed and included in ergonomic and workplace interventions (Hoe et al., 2018; Aas et al., 2011; Hoe et al., 2012). Apart from this aim, this study allowed us to invite office workers for subsequent studies.

In the following studies, PPT, TSP, and CPM were assessed to evaluate sensitization, which was present in office workers with chronic trapezius myalgia, but mostly in those with moderate pain intensity. Remarkably enough, the same groups revealed less MVC in UT and LT than the control group.

Finally, the last study assessed sensitization individually. This was possible with PPT reference values, TSP cut-off points, and analysed CPM as a percentage change in PPT from the literature and from our third study. There were office workers with CNP without any QST finding, which means a peripheral sensitization, indicating for a "button-up" approach. On the contrary, office workers had one and two QST findings, suggesting a central sensitization, an indication for a "button-up" and an "top-down" approach. The office workers with more QST findings were those with more pain intensity. The same was verified in the moderate pain intensity group in the previous study. Thus, an office worker with CNP self-reporting a moderate to severe pain intensity should draw the clinician's attention for a possible central sensitization process in the clinical practice.

Each one of the studies includes a specific discussion, and this chapter adds an integrated analysis of all of them, the main QST findings firstly, and then the remaining outcomes. As this brief overview, the discussion will bring about implications for the clinical practice. Furthermore, this chapter also describes the limitations of this thesis and the implications for clinical practice and future research.

9.2 Pressure Pain Threshold

The systematic review and meta-analysis showed non-significant changes in PPTs assessed at upper trapezius, extensor carpi ulnaris and tibialis anterior in office workers with CNP comparing with healthy office workers. Moreover, the review provides PPT reference values for upper trapezius and tibialis anterior for office workers with CNP. Those findings were important for further research. Since the sample size was much too small, it was necessary to provide more data. The reference values allow us to assess widespread pressure hyperalgesia in the following studies (Neziri et al., 2011; Waller et al., 2016).

In the third study (Chapter 6), there was a lower PPT in the chronic trapezius myalgia group and in the moderate pain group compared with the other groups. The findings of the chronic trapezius myalgia group were in line with previous studies (Leffler et al., 2003; Sjörs et al., 2011). In chronic trapezius myalgia, there were high levels of inflammatory mediators (Rosendal et al., 2005; Shah et al., 2005; Gerdle et al., 2008; Larsson et al., 2008; Shah et al., 2008; Ghafouri et al., 2010; Sjøgaard et al., 2010; Gerdle & Larsson et al., 2012; Gerdle et al., 2014; Gold et al., 2016), which might explain our results.

In the study from Gerdle et al. (2014), there was a difference in PPT in the upper trapezius, but not in tibialis anterior between subjects with trapezius myalgia and healthy controls. This study had a larger sample size compared with the mentioned studies. There was an increase of pro-inflammatory cytokines, interleukin-6 (IL-6), which seems to inhibit GABA, enhancing synaptic transmission in the lamina II neurons of the dorsal horn inducing central sensitization (Kawasaki et al., 2008). In our study, the lower PPTs in the upper trapezius, in the chronic trapezius myalgia subjects compared with chronic non-specific neck pain and controls, reinforce the possibility that sensitization may contribute to this difference.

The reference values from the systematic review and from the literature (Neziri et al., 2011; Waller et al.; 2016) allow us to recognize 33 office workers with hypersensitivity PPT values in the upper trapezius and the tibialis anterior (Chapter 8). In a non-painful region in subjects with CNP, the reference values from the tibialis anterior, allow us to recognize widespread pressure hyperalgesia in the clinical practice, a signal of central sensitization (Arendt-Nielsen et al., 2011; 2018).

A lack of standardized protocols with reference values is one of many barriers to implementing research results in clinical practice (Arendt-Nielsen & Yarnitsky, 2009; Cruz-Almeida & Fillingim, 2014; Arendt-Nielsen et al., 2018; Chimenti et al., 2018). From the systematic review, only two studies compared PPT in the extensor carpi ulnaris between office workers with CNP and healthy controls. This PPT point is considered to be a distal point from a pain localized in the neck region. In the third study, the PPT in the extensor carpi ulnaris was lower in the chronic trapezius myalgia group and in the moderate pain intensity group than the other groups, which was in accordance with the result from the systematic review.

Overall, from the literature and this research project, PPT reference values from the upper trapezius, the tibialis anterior, and an inference can be made for the extensor carpi ulnaris. Thus, this protocol can be applied at least for this specific population with neck pain. Our results are in line with a recent systematic review and meta-analysis from Xie et al. (2020), which found moderate-quality evidence of widespread pressure hyperalgesia in PPTs in the tibialis anterior when comparing patients with non-traumatic neck pain with healthy controls. This review were included patients with acute and chronic pain, and a careful extrapolation is required to our results.

Finally, gender and age are important aspects to discuss. In the literature, several studies reported PPTs were lower in healthy women when compared with healthy men (Rolke et al., 2006; Neziri et al., 2012; Racine et al., 2012; Tham et al., 2016; Waller et al., 2016). Gender also impacts other painful conditions such as knee osteoarthritis (Frey-Law et al., 2017), tension-type headache, and migraine (Andersen et al., 2015), adolescents with chronic pain (Tham et al., 2016). Our third study (Chapter 6) showed a difference between genders when comparing the control group with the symptomatic groups. For this reason, gender was a covariate to reduce this variability. So, it is fundamental to integrate gender when assessing PPT. In the literature, there are PPT reference values for males and females (Neziri et al., 2012; Waller et al., 2016). Our systematic review provides PPT reference values, mainly for female office workers with CNP. Nevertheless, in our third study (Chapter 6), there were no PPT differences in gender in the symptomatic groups. Still, there were differences in PPT in both the upper trapezius points and the extensor carpi ulnaris between the chronic trapezius myalgia group and non-specific chronic neck pain group.

Age is another important aspect to take into consideration when assessing PPTs. Pain threshold increases with age (Lautenbacher et al., 2017). In the second study (Chapter 5), “age between 50-65 years” was a risk factor for neck pain in office workers. In the following studies, the mean age was below 45.6 years without any statistical difference concerning age between groups. In the fourth study (Chapter 7), age was a covariate for assessing the difference in muscle strength in female office workers. Controlling both variables was important to conclude that the presence of widespread hyperalgesia assessed by lower PPT in tibialis anterior explained some of the variability of muscle strength in upper trapezius muscle in office workers with CNP.

9.3 Temporal Summation of Pain

Temporal summation of pain (TSP) reflects the wind-up processes in dorsal horn excitability, which measures increased central pain (Arendt-Nielsen et al., 2018). In the third study (Chapter 6), there was a significantly higher TSP in the moderate pain group when compared with the mild pain group and control group. Despite a higher TSP in the chronic trapezius myalgia group and non-specific neck pain compared with the control group, there was no statistical difference between groups. In the fifth study (Chapter 8), almost half of the office workers with CNP had a positive TSP finding.

TSP can be elicited by different stimuli such as thermal, electrical, or pressure (Graven-Nielsen & Arendt-Nielsen, 2010; Arendt-Nielsen et al., 2018). The TSP test-retest reliability in healthy individuals demonstrated higher reliability in thermal TSP by a Heat-Evoked Potential Stimulator (Kong et al., 2013); a good to excellent intraclass correlation coefficient (ICC) (0.60-0.90) by a computer-controlled cuff pressure algometry (Graven-Nielsen et al., 2015); poor to excellent ICC (0.20-0.91) by an electronic algometer (Middlebrook et al., 2020); good to excellent reliability by an analog pressure algometer (Cathcart et al., 2009); and moderate to good reliability in long term reliability by a pinprick in the lumbar spine (Marcuzzi et al., 2017; Nothnagel et al., 2017).

Therefore, different methods have proven to be reliable for TSP measurement, including the method used in this thesis, demonstrated by the studies of Marcuzzi et al. (2017) and Nothnagel et al. (2017) conducted in healthy subjects. Nevertheless, the reliability in the study of Middlebrook et al. (2020) increased in subjects with acute musculoskeletal trauma with a good to excellent ICC (0.69-0.91). In subjects with neurologic conditions, TSP assessed by pinprick demonstrated good test-retest reliability (Geber et al., 2011). Further studies are necessary to analyse TSP reliability in chronic conditions.

Besides reliability, another important point to discuss is gender. As mentioned before, there are differences in PPT between genders. Such differences between genders were evident, for instance, when measured by cuff pressure algometry (Graven-Nielsen et al., 2015). Nevertheless, there were no differences in gender in healthy subjects measured by pinprick (Rolke et al., 2006) and computer-controlled pressure algometer (Nie et al., 2005). However, there was a difference between gender in the study of Sarlani & Greenspan (2002), who measured TSP by mechanical stimuli with a sharp probe on the fingers resulting in a higher TSP in females.

So, the area of stimulation is also important to consider when measuring TSP according to the mechanical stimulus device (Nie et al., 2009). Thus, not only when comparing genders but also symptomatic and asymptomatic subjects. Patients with neck pain demonstrated enlargement of reflex receptive fields compared with healthy subjects (Manresa et al., 2013). The receptive field area of a human group III and IV nociceptors is approximately 5cm^2 (Marchettini et al., 1996), and the cutaneous polymodal c-fiber is 4cm^2 (Olausson 1998). There is an interrelation between spatial summation and temporal summation, causing pain intensity (Nie et al., 2009).

Consequently, when assessing TSP with a manual tool, such as an algometer or pinprick, all the mechanical stimulus sequence should be confined within an area of approximately $2cm^2$, to stimulate the same nociceptors population (Sarlani & Greenspan, 2002). In the study of Nie et al. (2009), there was a facilitated TSP in healthy subjects with probe sizes larger than $2cm^2$ in the upper trapezius and in the tibialis anterior (Nie et al., 2009). This reflects an advantage of a manual pinprick to assess TSP.

Another concern is the inter-stimulus intervals, mainly when used as a manual tool (algometer or pinprick). The inter-stimulus intervals of 30s induced TSP in the upper trapezius (Nie et al., 2009) and the tibialis anterior (Nie et al., 2005, 2009), mainly with small probe areas (Nie et al., 2009). Other studies also found TSP with inter-stimulus until 6s (Sarlani & Greenspan, 2002). Again, this is easily achievable with a manual device.

Hence in this thesis, TSP was assessed by means of a manual tool to be reliable in long-duration (Marcuzzi et al., 2017), with a small contact area, with no concerns about the duration of the inter-stimulus. Finally, it is necessary to describe the method to calculate TSP, a crucial aspect of the clinical practice. There are different methods for carrying out this calculation: the difference in pain intensity between the first and the last stimuli (Kurien et al., 2018; Petersen et al., 2015, 2018); a wind-up ratio as the mean rating of a series of 10 stimuli by the mean rating of a single stimulus, repeated five times (Rolk et al., 2006); or the ratio from the pain intensity from the 8 to 10 stimuli with the pain intensity from the first four stimuli (Graven-Nielsen et al., 2015).

In our previous study, enhanced TSP was present if the increase from the first to the last stimulus was 2 points in VAS (Rabey et al., 2019). This cut-off point to assess the presence of TSP is useful and easy to be implemented in clinical practice. Further research will be needed to determine if this is actually the ideal cut-off point regarding the different TSP tools and methods as described. Nevertheless, this cut-off point was used with a pinprick. In clinical practice, the problem of calculating a wind-up ratio comes up when the self-reported pain intensity of the first stimulus by the patient is zero. Typically, another heavier pinprick is used (Marcuzzi et al., 2017). The first stimulus not causing pain often occurred during our procedure in symptomatic and asymptomatic office workers.

The aforementioned is relevant in clinical practice. It is also important to mention that in the study of Middlebrook et al. (2020), subjects in both groups (healthy and acute musculoskeletal trauma) stopped the procedure due to high pain intensity during TSP. This also happened during our procedure, with a few office workers have asked to stop the measurement.

9.4 Condition Pain Modulation

In humans, CPM assesses the balance of descending pain inhibitory and facilitatory pathways (Yarnitsky et al., 2010; Arendt-Nielsen et al., 2011, 2015, 2018). CPM is based on applying a noxious conditioning stimulus and measured the analgesic effect on a pre-and post-painful test stimulus (Yarnitsky et al., 2010; Nir & Yarnitsky, 2015). The standardized terminology to describe the lower brainstem mediated inhibitory mechanism is "diffuse noxious inhibitory controls" (Yarnitsky et al., 2010; Arendt-Nielsen et al., 2011; Nir & Yarnitsky, 2015). Thus, an impairment of the descending pain modulatory pathways contributes to the development of central sensitization.

In the third study (Chapter 6), the CPM results were similar to other studies in office workers with CNP (Ge et al., 2014; Heredia-Rizo et al., 2019). The studies from Shahidi et al. (2015) and Shahidi & Maluf (2017), in a twelve-month prospective cohort study with office workers, considered CPM a risk factor for developing chronic interfering neck pain. Interestingly enough, secondary analysis in the study from Shahidi et al. (2015), compared office workers with CPM with a healthy group, CPM was no longer a significant predictor for CNP development.

In chronic pain situations, an average of around 70% of subjects revealed an impaired CPM when compared to healthy controls (Lewis et al., 2012); in situations of fibromyalgia, this percentage was 65% when compared to healthy controls (O'Brien et al., 2018). In chronic non-specific low-back pain, there is more variability than healthy controls (Bandt et al., 2019), which can follow a similar pattern in CNP. Moreover, the recent systematic review from Fernandes et al. (2019) reported an average of 69% of an efficient CPM with non-significant correlations with pain intensity in chronic pain conditions. However, this review only included four studies researching CPM in chronic non-specific neck pain: one of them was a whiplash-associated disorder, another one a chronic non-specific neck pain, and the last two a combination of low back and neck pain. Consequently, further studies are necessary to investigate CPM in chronic non-specific neck pain.

Therefore, it is important to compare the CPM protocols, despite CPM being a reliable measure (Kennedy et al., 2016), with recommendations for CPM testing (Yarnitsky et al., 2015). The conditioning stimulus used was a cuff-pressure (Ge et al., 2014; Heredia-Rizo et al., 2019) in the non-painful/non-dominant arm (Ge et al., 2014), and in the contralateral leg (Heredia-Rizo et al., 2019), and the cold pressor test with the non-dominant hand in an ice water bath at 4ºC (Shahidi et al., 2015; Shahidi & Maluf, 2017). All the studies measured PPT before and after the conditioning stimulus with the same size probe of 1 cm^2, which is reliable as a test stimulus in CPM (Klyne et al., 2015). Somewhat different was the study from Ge et al. (2014), where the CPM effect was measured in tibialis anterior, while in other studies, measurement was done in the dominant upper trapezius, as performed in our study. Despite these differences, the test-retest reliability of both conditions was very high, more reliable compared with other test types, without differences between both procedures (Imai et al., 2016). As for the CPM results for PPT and cuff-pressure as test stimulus with the cold pressor test as the conditioning stimulus, both produce significant CPM effects (Imai et al., 2016), although the CPM effect can be higher with the cold pressor test (Oono et al., 2011).

As discussed in PPT and TSP, gender also affects CPM results, demonstrating less pain inhibition in healthy female subjects (Bulls et al., 2015; Graven-Nielsen et al., 2015; Hermans et al., 2016; Skovberg et al., 2017), and in female subjects with chronic low back pain (Martel et al., 2013) when compared with male subjects in the same testing conditions. Anyway, the samples for the studies that assess CPM in office workers mainly were composed of female subjects, explaining some of the results. Moreover, the CPM effect seems to be higher during the ovulatory phase of the menstrual cycle (Hermans et al., 2016). However, none of the studies mentioned in the discussion, our study included, considered the ovulatory phase when assessing CPM in female office workers.

Other variables are pain intensity and age. In the study from Ge et al. (2014), there was a correlation between pain intensity and less efficient CPM. In our third study (Chapter 6), there was no correlation with pain intensity. However, in the last study (Chapter 8), the quantitative sensory testing group 2 (QST2 group) had a significantly higher intensity pain with more CPM positive findings when compared with quantitative sensory testing group 1 (QST1 group). In other studies on office workers (Shahidi et al., 2015, Shahidi & Maluf, 2017); Heredia-Rizo et al., 2019), there was no report about pain intensity. Therefore, further studies are necessary. Nevertheless, as already mentioned, there were non-significant correlations between CPM and pain intensity in chronic pain conditions (Fernandes et al., 2019).

As far as age is concerned, young-aged healthy individuals (20-40 years) demonstrated a significant CPM effect when compared with the middle-aged (41-60) and old-aged (61-80 years), without differences between the middle-aged and old-aged (Grashorn et al., 2013). In fact, there was moderate evidence that younger adults have a better CPM effect when compared with older adults (Hermans et al., 2016). Moreover, our study population, like the ones in the studies from Ge et al. (2014) and Heredia-Rizo et al. (2019), had a mean age higher than 40

years, contrasting with those in the studies from Shahidi et al. (2015) and Shahidi & Maluf (2017) with a mean age lower than 30 years. This can further explain the CPM results.
A premature withdrawal from the cold pressor test increases the CPM effect (Skovberg et al., 2017). Our third study (Chapter 6) showed a significant difference in hand immersion time being higher in the asymptomatic group than all the symptomatic groups. Therefore, this could increase the CPM effect in the symptomatic groups. The withdrawal time was not reported in the other studies that measured CPM in office workers.

This discussion demonstrated the variability in CPM, in healthy subjects, in chronic conditions, between female and male subjects and between younger and older ages. Therefore, there is a need for reference CPM values for the clinical practice to assess dysfunctional pain modulation. Schliessback et al. (2019) study provide percentiles for CPM with the cold pressor test as the conditioning stimulus for assessing dysfunctional pain modulation. In our last study, we used the 5th percentile proposed by Schliessback et al. (2019) as a cut-off point for a normal CPM, similar to the third study's CPM findings (Chapter 6), despite, this value is very conservative in identifying dysfunctional pain modulation (Schliessback et al., 2019). Nevertheless, in the last study (Chapter 8), twenty-one office workers reduced 7.5% of the PPT value after the cold pressor test, compared with the pre PPT value. From those, sixteen office workers also had another QST finding, which correlates to an impairment in the descending pain modulatory pathways (Arendt-Nielsen et al., 2010, 2105a, 2015b). Thus, a negative CPM value not necessarily reflects an abnormal CPM (Schliessback et al., 2019), but if an office work with CNP, self-reporting a moderate pain intensity plus other QST test finding, can be considered a consistent result for impaired endogenous pain modulation.

9.5 Pain intensity

In the third study, the moderate pain intensity group demonstrated widespread pressure hyperalgesia by a lower PPT in all points and a facilitated temporal summation compared with the other groups. Finally, in the last study (Chapter 8), the QST2 group (more QST findings) had a significantly higher pain intensity when compared with the other groups. The consistency of those findings indicated a central sensitization in office workers with moderate pain intensity, a characteristic in nociplastic pain (Kosek et al., 2016).

In the PPT discussion, it was mentioned that there was some evidence that an increase in IL-6 present in chronic trapezius myalgia could induce central sensitization. A recent systematic review and meta-analysis demonstrated a low quality of evidence with a large effect size (SMD 0.84) and a medium effect size (SMD 0.59) for an increased concentration of IL-6 and TNF-a respectively, when comparing chronic neck pain with controls (Farrell et al., 2020). The downgrading of evidence was attributed to the small sample size (n=66) and the low-quality studies. Also, the meta-analysis included three studies, one of them with whiplash patients. These results must therefore be interpreted with care.

Moreover, these inflammatory markers were not associated with pain intensity (Farrell et al., 2020). According to the same review, there was moderate evidence of C-reactive protein in CNP. There was no meta-analysis describing the effect size, and these results were gathered from three studies, two of which were carried out with whiplash patients. The other study found a moderate correlation between C-reactive protein and pain intensity (Matute Wilander et al., 2014). Interestingly, in both studies of the whiplash condition, the C-reactive protein was not associated with pain intensity (Farrell et al., 2020). The population included in the study from Matute Wilander et al. (2014) was composed by female supermarket cashiers, different from our study population.

So, we can argue that there is evidence that inflammatory markers in office workers with CNP are responsible for higher pain intensity. As discussed in the third study (Chapter 6), TSP and disability were associated with pain intensity. In prospective longitudinal studies, stress and disability were associated with CNP (Fanavoll et al., 2016; Moloney et al., 2018; Svedmark et al., 2018). In the last study (Chapter 8), in the QST2 group, there was an association between pain intensity with the rumination subscale in the Pain Catastrophizing Scale. In previous studies, there was an association between pain catastrophizing with higher pain intensity in subjects with CNP (Thompson et al., 2010; Park et al., 2016). In the study from Dimitriadis et al. (2015) in patients with idiopathic CNP, catastrophizing was not associated with pain intensity but rather with disability. Nevertheless, in a recent review of systematic reviews of prospective cohort studies, pain catastrophizing was a longitudinal psychological risk factor associated with pain intensity and dysfunction in persistent musculoskeletal pain cases (Martinez-Calderon et al., 2020).

It seems there is a relationship between pain catastrophizing with higher pain intensity, disability, stress and sleep (Park et al., 2016), as will be discussed. These have implications in clinical practice and should be assessed for better treatment strategies. For example, to reduce pain catastrophizing, a recent systematic review demonstrated moderate evidence with a medium effect size for Cognitive Behaviour Therapy and Multimodal treatment versus waitlist/usual care at follow-up between 6 to 12 months; and moderate to strong evidence with medium to large effect size for Acceptance and Commitment Therapy, Cognitive Behaviour

Therapy and Multimodal treatment versus active controls at follow-up between 6 to 12 months (Schütze et al., 2018). However, in the mentioned systematic reviews, there was one study from Gustavsson et al. (2010), with subjects with CNP that received Cognitive Behaviour Therapy, which was not specific to office workers. Therefore, further research is needed to assess the effectiveness of reducing pain catastrophizing and pain intensity in office workers with CNP.

9.6 Disability, Stress and Sleep

In the third study (Chapter 6), disability was an independent variable associated with pain intensity in all symptomatic groups. Overall, stress and sleep were independent predictors for disability in the pain condition groups. From prospective studies, higher perceived stress was a predictor for disability and CNP development in workers (Fanavoll et al., 2016; Moloney et al., 2018; Svedmark et al., 2018). In office workers, stress is a work-related risk factor for neck pain (Hannan et al., 2005; Hargberg et al., 2007; Eltayeb et al., 2009; Harcombe et al., 2010; Sihawong et al., 2016). In a recent review of systematic reviews, stress and sleep were longitudinal psychological factors associated with pain intensity in persistent musculoskeletal pain (Martinez-Calderon et al., 2020). In addition, there is growing evidence that stress and sleep originate pain sensitization (Smith et al., 2007; Finan et al., 2013; Schuh-Hofer et al., 2013; Curatolo et al., 2015; Schrimpf et al., 2015; Sivertsen et al., 2015; Hven et al., 2017; Staffe et al., 2019).

Currently, there are two models linking stress with pain: allostatic overload (stress overload) and fear-avoidance. These models are not independent, overlapping and sharing the same long-term consequences (Abdallah & Geha, 2017). In this thesis, there was no outcome to measure fear of movement. On the other hand, there was strong evidence between kinesiophobia and pain intensity and disability levels in chronic musculoskeletal pain (Luque-Suarez et al., 2019). Nevertheless, from our second study (Chapter 5), the "number of working hours on a computer without a break", workstations layout variables, and from the third study (Chapter 6), stress, somatic stress and cognitive stress were higher in all the symptomatic groups when compared with the asymptomatic group, so that it is plausible to assume a stress overload in those office workers.

Multiple and complex physiological interactions exist between stress and pain. It is out of the purpose to discuss all of these physiological phenomena, even because this thesis did not collect physiologic outcomes. Nevertheless, when possible, it is necessary to integrate with CNP. Stress and chronic pain are modulated in the corticolimbic system and share a similar circuitry within this system (Vachon-Presseau et al., 2018). In chronic maladaptive stress and chronic pain, there are findings of a decreased volume of the amygdala and hippocampus (Vachon-Pressau et al., 2013, 2016; Abdallah & Geha, 2017), which can amplify the pain intensity in chronic conditions (Vachon-Pressau et al., 2016; Abdallah & Geha, 2017). In non-traumatic chronic non-specific neck pain, there is no evidence of changes within these brain areas (De Pauw et al., 2017; Coppieters et al., 2018). However, in these studies, the stress levels were not reported.

The stress response activates the hypothalamic-pituitary-adrenal axis to release the stress hormone cortisol from the adrenal gland. In chronic stress, this axis becomes dysfunctional, increasing or decreasing the basal cortisol levels (Woda et al., 2016). In addition, the stress hormones induce changes in the immune system, inhibiting the helper-T cells (Th1) in producing pro-inflammatory cytokines or induce the helper-T cells (Th2) to upregulate anti-inflammatory cytokines (Woda et al., 2016). Chronic stress deregulates this balance in different directions, and such changes have been observed in various chronic pain conditions (Woda et al., 2016; Timmers et al., 2019). As mentioned before, there are increased inflammatory biomarkers in CNP (Matute-Wilander et al., 2014; Farrell et al., 2020) and non-specific low back pain (Lim et al., 2020; Morris et al., 2020). Moreover, these findings suggest that sustained inflammation, even at low levels, can originate chronic widespread pain (Sibille et al., 2016; Gerdle et al., 2017). In the second study (Chapter 5), there was a high prevalence of office workers with pain in three or more body regions.

Another important link is between cortisol and sleep. A good sleep pattern is associated with an optimal diurnal release of cortisol (Adam & Kumari et al., 2009). In addition, there is an association between sleep impairment and the increased allostatic load (Suvarna et al., 2020). Moreover, chronic pain with sleep impairment increased pain severity, long duration of pain, and disability (Burgess et al., 2019; Husak & Bair, 2020). Finally, from a longitudinal study, subjects with a localized pain with associated insomnia increased the risk to develop widespread pain, being the risk higher as the insomnia severity (Wiklund et al., 2020).

9.7 Muscle strength

The fourth study (Chapter 7) demonstrated a decrease in MVC in UT and LT in the chronic trapezius myalgia group and in the moderate pain intensity group compared with the asymptomatic office workers. However, decreased MVC was not a feature of all office workers with chronic neck pain, meaning a previous assessment is absolutely necessary. For this purpose, further research is required for MVC normative values for office workers with CNP. This can explain the mixed results in strengthening exercises in this population, which will be discussed.

A recent systematic review and meta-analysis specific to office workers found moderate evidence with a medium effect size that workplace strengthening exercises effectively reduced neck pain with a more significant effect when the exercises were directed at the neck/shoulder region (Chen et al., 2018). However, as mentioned in the literature review (chapter 2), there was a bias in the meta-analysis in this systematic review, which reduced the effect size.This analysis followed the result from another recent systematic review with meta-analysis. They found low-quality evidence with a medium effect size of workplace strengthening exercises and workstations modifications comparing with no intervention in reducing neck pain in office workers in the short and medium-term (Frutiger & Borotkanics, 2020).

Nevertheless, both systematic reviews included good-quality randomized control trials with low risk of bias encompassing strengthening at the workplace with a positive effect in reducing neck pain in office workers (Andersen C. H. et al., 2012, 2014; Andersen L. L. et al., 2008, 2011; Sihawong et al., 2014). The study from Sihawong et al. (2014) combined endurance training at the workplace and stretching at home. The study from Andersen C. H. et al. (2014) comprised functional strengthening exercises to strengthen LT and serratus anterior muscles and not UT, reporting an increase in shoulder elevation strength. The other studies included strengthening training which strengthens the deltoid muscle, trapezius muscle (mainly UT but also middle trapezius and LT), and serratus anterior.

Likewise, two of these articles (Andersen L. L. et al., 2008; Andersen C. H. et al., 2012) were included in the last Cochrane systematic review for mechanical neck pain with moderate quality of evidence with a benefit for CNP with specific strengthening exercise for cervical and scapulothoracic muscles (Gross et al., 2016). Also, there is evidence for reduced neck muscle strength in subjects with CNP (Miranda et al., 2019).

So, the question arises if office workers benefit more from strength exercise than others, which is important for research and clinical practice. From our study, there were office workers with CNP with no deficit of strength compared with healthy office workers. Probably, those will not benefit so much as the office workers with an apparent strength deficit.

In a different line of reasoning, one should consider whether a specific type of exercise will have an acute, medium or long term analgesic effect. Exercise-induced hypoalgesia is characterized by a decrease in sensitivity after a painful exercise. The underlying mechanisms of exercise-induced hypoalgesia consist of activating the endogenous opioid system and the activation of the endocannabinoid system and serotonin and norepinephrine release (Koltyn et al., 2014). In laboratory-based studies, exercise-induced hypoalgesia is quantified by assessing pain sensitivity measurement, as PPT, TSP, CPM before and after a specific dose of exercise causing a pain sensation. The standard exercises used are higher intensity aerobic exercise, and a dynamic or isometric resistance exercise in the painful area or, more interestingly, in a distal non-painful area (Rice et al., 2019).

Exercise-induced hypoalgesia is commonly verified in a healthy pain-free population but is quite variable in chronic pain populations. In subjects with shoulder myalgia, an isometric shoulder abduction exercise and a wall squat session demonstrated no difference in PPT, after the shoulder exercise and an increase in PPT after the wall squat (Lannersten & Kosek, 2010). These results mean a normal activation of the endogenous pain mechanisms but a lack of pain inhibition after the contraction of the painful muscle (Lannersten & Kosek, 2010). In subjects with neck pain after a shoulder abduction exercise, there were decreased PPTs in the painful local site and in the distal non-painful sites (Christensen et al., 2017).

A recent systematic review from Polaski et al. (2019) for exercise-induced hypoalgesia in chronic conditions, included neck pain, analysed the time of exercise as 120 minutes per week, the frequency of 3 times per week, with a duration of 15 weeks as an optimum prediction dose for an analgesic effect. Still, there was insufficient evidence for a strong effect size, with a modest significant correlation between duration and pain effect for neck pain (Polaski et al., 2019). Moreover, this systematic review only included one study with office workers. Further studies are necessary to quantify exercise-induced hypoalgesia in office workers with CNP. Nevertheless, the study described in Chapter 8 provides tools to assess individual pain sensitivity and an increased sensitivity after exercise; especially strength exercises aimed to increase muscle strength can increase pain intensity and constitute a barrier for exercise adherence (Rice et al., 2019). This has important implications for the clinical practice when design rehabilitation interventions for office workers with CNP.

9.8 Strengths and Limitations

This thesis presents a number of strengths. The systematic review and meta-analysis (Chapter 4) provide PPT reference values to recognize widespread pressure hyperalgesia in office workers with CNP. However, the PPT assumptions between office workers with CNP compared with healthy workers were based on a small sample of existing studies. Therefore, further studies were necessary, which were conducted in the third study (Chapter 6). This study had a higher sample size when compared with the cross-sectional studies mentioned in the systematic review. Thus, the only study that measured TSP in office workers with CNP was published in 2019 with a small sample size (Heredia-Rizo et al., 2019). The collection of TSP data started before 2019 with higher sample size. Also, more studies were necessary to quantify CPM in CNP. This thesis provides further information on TSP and CPM in office workers with CNP.

To our knowledge, the third and fourth studies (Chapter 6 and 7, respectively) were the first to assess the pain mechanisms, differentiating pain conditions with pain intensities in office workers with chronic neck pain. Concluding that the office workers with moderate pain intensity had no different significant variables from the pain conditions provide a direct shortcut for the clinical practice. Moreover, the clinical quantitative sensory testing tools used with reference values and cut-off points can assess and differentiate the pain mechanisms. Finally, the second study (Chapter 5) demonstrated the high prevalence of neck pain in Portuguese office workers and occupational risk factors associated with the development of neck pain.

Concerning the limitations, apart from those mentioned in each study, this research project lacks a longitudinal study to analyse the mentioned associations over time. The main reason for this was the difficulty in recruiting office workers for our project.

The principal researcher performed the clinical examination and was not blind to office workers group allocation. Overcoming this study limitation, which is a source of detection bias, was one of the reasons why in studies 3 and 4 (Chapter 6 and 7, respectively), the sample size was analysed in terms of pain condition groups and pain intensity groups.

The mainstream of this thesis was the pain sensitivity measurement. Since the project was not funded, the amount of time required to measure all the variables per office worker was an obstacle to their recruitment, mainly in the private sector. As a result, the research team was compelled to diminish the total number of questionnaires to reduce the data collection time. Typically, this type of research would include more different questionnaires, allowing a better comparison between studies.

Finally, it was not possible to measure all the outcomes in the same period of the day and on the same day in the week. Some results might be different if it had been possible to measure some of the variables at the outset of the working week/day.

9.9 Implications for the Clinical Practice

Assessing the pain mechanisms in cases of chronic pain is an essential step in the decision-making process to individual care rather than a diagnosis (Arendt-Nielsen et al., 2018; Chimenti et al., 2018). For this purpose, this thesis used Quantitative Sensory Testing to assess and differentiate the pain mechanisms with reference values, cut-off points, and clinical bedside tools that can be easily transferable to the clinical practice. Office workers with chronic neck pain self-reporting a moderate pain intensity demonstrated signals of a nociplastic pain process.

A growing body of evidence indicates that stress and sleep impairment are risk factors associated with chronic neck pain and disability. Moreover, pain intensity was associated with reduced muscle strength. In addition, there are modifiable risk factors related to computer work and workstation layout associated with neck pain. Rehabilitation or treatment strategies to improve these outcomes in office workers with chronic neck pain should be implemented in pain management.

Finally, the prevalence of musculoskeletal pain, the number of body segments with pain, the duration of pain, and the lack of current treatment to reduce pain and improve the function of the Portuguese office workers suffering from chronic pain should be a concern for decision-makers, employers, and healthcare professionals.

9.10 Implications for Future Research

Several recommendations for future research emerged through the discussion, which can be summarised as follows:

- Longitudinal studies to assess nociplastic pain in office workers with chronic neck pain.
- The ideal cut-off point to assess facilitated TSP. Thus, it should be conducted regarding the different methods and equipment. Moreover, it is necessary to analyse TSP reliability in chronic conditions.
- Further studies are necessary to investigate CPM in chronic non-specific neck pain.

Finally, the hallmark of this thesis was the need to assess the pain mechanisms in office workers with CNP for more effective interventions.

9.11 Conclusion

Office workers with chronic neck pain self-reporting a moderate pain intensity demonstrated signals of a nociplastic pain. This was characterized by widespread pressure hyperalgesia and facilitated temporal summation. Thus, it is more important to classify the pain mechanisms rather than differentiate them from chronic trapezius myalgia with non-specific chronic neck pain. The assessment of the pain mechanism was possible with reference values and cut-off points with the quantitative sensory testing. Moreover, nociplastic pain was associated with pain intensity, pain rumination, and reduced muscle strength. In addition, disability, stress, and sleep provide insight into the fundamental aspects of chronic neck pain in office workers with pain. Finally, there are modifiable risk factors related to computer work and workstation layout associated with neck pain.

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APPENDICES

Appendix I

Systematic review search strategy

Search Strategy

Keywords – Office worker, computer worker, neck pain, pressure pain threshold, algometry.

PubMed

“Office worker” [Mesh] OR office worker*[tiab] OR office worker* [ot] “Computer worker” [Mesh] OR computer worker*[tiab] OR computer worker* [ot] “desk-based workers” [Mesh] OR “desk-based workers” [ot] OR “desk-based workers” [tiab]

AND

“neck pain” [Mesh] OR neck pain*[tiab] OR neck syndrome*[tiab] OR neck dysfunction*[tiab] OR neck disorder*[tiab] OR cervical pain*[tiab] OR cervicodynia*[tiab] OR trapezius pain*[tiab] OR chronic trapezius myalgia*[tiab]

AND

"Pain Threshold"[Mesh] OR ppt*[tiab] OR pain threshold*[tiab] OR algomet*[tiab] OR ppt*[ot] OR pain threshold*[ot] OR algomet*[ot]

Appendix II

Systematic Review excluded studies after full text assessment

Table - Excluded studies after full text assessment

Main Author	Year	Study Type	Journal	Reason for exclusion
Beltran-Alacreu et al.	2018	Cross-sectional	Rev Assoc Med Bras	No office workers
Cabak et al.	2016	RCT	Ortop Traumatol Rehabil	Office workers with pain but no chronic pain
Cabak et al.	2017	Prospective observational study	Advs Exp. Medicine, Biology - Neuroscience and Respiration	Office workers with pain but no chronic pain
Cagnie et al.	2013	Prospective observational study	J Manipulative Physiol Ther	Office workers with pain but no chronic pain
Cerezo-Téllez et al.	2016	RCT	J Man Manip Ther	Office workers with pain but no chronic pain
Chua et al.	2012	Cross-sectional	J Musculoskelet Pain	No ffice workers
De Meulemeester et al.	2017	RCT	J Manipulative Physiol Ther	No possible to determine the PPT points. Author was contacted and confirmed.
Go et al.	2016	RCT	J Phys Ther Sci	Office workers with neck and shoulder pain and no chronic pain
Hägg & Åström,	1997	Cross-Sectional	Int Arch Occup Environ Health	No possible to determine if all the PPT data is from the chronic pain group
Kocur et al.	2017	RCT	Work	Office workers with pain but no chronic pain
Kocur et al.	2018	Cross-sectional	J Phys Med Rehabil	Office workers with pain but no chronic pain
Kojidi et al.	2016	RCT	J Bodyw Mov Ther	Office workers with pain but no chronic pain
Main Author	**Year**	**Study Type**	**Journal**	**Reason for exclusion**

Kojidi et al.	016	RCT	J Chiropr Med	Office workers with pain but no chronic pain
León-Hernández et al.	2016	RCT	Braz J Phys Ther	No office workers
Levoska	1993	Cross-sectional	Clin J Pain	Office workers with pain but no chronic pain
Li et al.	2017	RCT	Int Arch Occup Environ Health	No possible to determine the PPT points
Madeleine et al.	1998	Cross-sectional	Eur J Pain	No office workers
Moloney et al.	2010	Case-control observational study	BMC Musculoskelet Disord	Study protocol
Moloney et al.	2013	Cross-sectional	Clin J Pain	Nonspecfic arm pain and cervical radiculopathy
Moloney et al.	2015	Cross-sectional	Arch Phys Med Rehabil	Nonspecfic arm pain and cervical radiculopathy
Myburgh et al.	2012	RCT	Chiropr Man Therap	Office workers with pain but no chronic pain and no PPT data
Park et al.	2018	RCT	J Back Musculoskelet Rehabil	Office workers with pain but no chronic pain
Schomacher et al.	2013	Cross-sectional	Clin J Pain	No office workers
Silvério-Lopes	2008	Cross-sectional	Rev Bras Fisiot	No office workers

Appendix III

Description of the quality assessment tool: Downs & Black (1998)

Table – Description on the quality assessment tool: Downs & Black (1998)

Items	**Score**
Reporting	
1. Is the hypothesis/aim/objective of the study clearly described?	Yes: 1 No: 2
2. Are the main outcomes to be measured clearly described in the Introduction or Methods section?	Yes: 1 No: 2
3. Are the characteristics of the patients included in the study clearly described?	Yes: 1 No: 2
4. Are the interventions of interest clearly described?	Yes: 1 No: 2
5. Are the distributions of principal confounders in each group of subjects to be compared clearly described?	Yes: 2 Partially: 1 No: 0
6. Are the main findings of the study clearly described?	Yes: 1 No: 2
7. Does the study provide estimates of the random variability in the data for the main outcomes?	Yes: 1 No: 2
8. Have all important adverse events that may be a consequence of the intervention been reported?	Yes: 1 No: 2
9. Have the characteristics of patients lost to follow-up been described?	Yes: 1 No: 2
10. Have actual probability values been reported (e.g. 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001?	Yes: 1 No: 2
External validity	
11. Were the subjects asked to participate in the study representative of the entire population from which they were recruited?	Yes: 1 No: 0 UD: 0
12. Were those subjects who were prepared to participate representative of the entire population from which they were recruited?	Yes: 1 No: 0 UD: 0

13. Were the staff, places, and facilities where the patients were treated, representative of the treatment the majority of patients receive?	Yes: 1 No: 0 UD: 0
Internal validity (Bias)	
14. Was an attempt made to blind study subjects to the intervention they have received?	Yes: 1 No: 0 UD: 0
15. Was an attempt made to blind those measuring the main outcomes of the intervention?	Yes: 1 No: 0 UD: 0
16. If any of the results of the study were based on "data dredging", was this made clear?	Yes: 1 No: 0 UD: 0
17. In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients, or in case-control studies, is the time period between the intervention and outcome the same for cases and controls?	Yes: 1 No: 0 UD: 0
18. Were the statistical tests used to assess the main outcomes appropriate?	Yes: 1 No: 0 UD: 0
19. Was compliance with the intervention/s reliable?	Yes: 1 No: 0 UD: 0
20. Were the main outcome measures used accurate (valid and reliable)?	Yes: 1 No: 0 UD: 0
Internal validity (Confounding)	
21. Were the patients in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited from the same population?	Yes: 1 No: 0 UD: 0
22. Were study subjects in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited over the same period of time?	Yes: 1 No: 0 UD: 0
23. Were study subjects randomised to intervention groups?	Yes: 1

	No: 0 UD: 0
24. Was the randomised intervention assignment concealed from both patients and health care staff until recruitment was complete and irrevocable?	Yes: 1 No: 0 UD: 0
25. Was there adequate adjustment for confounding in the analyses from which the main findings were drawn?	Yes: 1 No: 0 UD: 0
26. Were losses of patients to follow-up taken into account?	Yes: 1 No: 0 UD: 0
Power	
27. Did the study have sufficient power to detect a clinically important effect where the probability value for a difference being due to chance is less than 5%?	$<n_1$ =0 n_1-n_2 =1 n_3-n_4 =2 n_5-n_6 =3 n_7-n_8 =4 n_8+ =5
Max achievable score	32

UD, Unable to determine. Based on Downs and Black (1998).

Appendix IV

Informed consent term for the online questionnaire

CONSELHO DE ÉTICA DA FACULDADE DE MOTRICIDADE HUMANA

EXEMPLO DE GUIÃO PARA A ELABORAÇÃO DO *CONSENTIMENTO INFORMADO LIVRE E ESCLARECIDO* PARA INVESTIGAÇÃO CIENTÍFICA COM SERES HUMANOS

Título do projeto ou estudo:

Nociplastic pain in office workers with chronic neck pain

Pessoa responsável pelo projeto:

Alexandre Maurício Passos Nunes

Instituição de acolhimento:

Faculdade de Motricidade Humana – Universidade de Lisboa

Este documento, designado **Consentimento, Informado, Livre e Esclarecido**, contém informação importante em relação ao estudo para o qual foi abordado/a, bem como o que esperar se decidir participar no mesmo. Leia atentamente toda a informação aqui contida. Deve sentir-se inteiramente livre para colocar qualquer questão, assim como para discutir com terceiros (amigos, familiares) a decisão da sua participação neste estudo.

Informação geral
Está a ser convidado(a) a participar num projecto de investigação no âmbito do Doutoramento em Motricidade Humana na especialidade de Reabilitação, da Faculdade de Motricidade Humana de Lisboa que pretende estudar e captar informação que ajude não só a melhorar o entendimento dos fatores causativos de problemas músculo-esqueléticos que aflige trabalhadores com computadores, do ponto de vista dos clínicos e investigadores, mas que permita, uma intervenção no local laboral de forma a prevenir e reduzir a incidência destes mesmos problemas.

A selecção para a participação baseia-se nos critérios de elegibilidade do estudo: adulto (25-60 anos), trabalho com computador pelo menos à mais de um ano e cerca de ¾ do período laboral ao computador. Este estudo para o qual estamos a solicitar a sua colaboração pretende caracterizar através de um questionário o seu posto de trabalho, o ambiente de trabalho, a forma como trabalha com computador e aspetos da sua saúde.
Qual a duração esperada da minha participação?
A sua participação terá uma duração aproximada de 10 a 15 minutos.
Quais os procedimentos do estudo em que vou participar?
Como mencionado será feito através de um questionário on-line.
A minha participação é voluntária?
A sua participação é voluntária e pode recusar-se a participar. Caso decida participar neste estudo é importante ter conhecimento que pode desistir a qualquer momento, sem qualquer tipo de consequência para si. No caso de decidir abandonar o estudo, a sua relação com a Faculdade de Motricidade Humana (FMH) não será afetada. Se for o caso, o seu estatuto enquanto estudante ou funcionário da FMH será mantido e não sofrerá nenhuma consequência da sua não-participação ou desistência.
Quais os possíveis benefícios da minha participação?
Alterações Ergonómicas no seu posto de trabalho e comportamentos durante o trabalho com computador de forma a reduzir ou evitar sintomas músculo-esqueléticos.
Quais os possíveis riscos da minha participação?
Não existe nenhum risco, e informamos que este questionário tem a aprovação da sua entidade patronal, sendo um parceiro nesta investigação, tendo o objetivo de reduzir o impacto de lesões músculo-esqueléticas nos seus trabalhadores com computadores.
Quem assume a responsabilidade, no caso de um evento negativo?
Não se aplica.
Há cobertura por uma companhia de seguros?
Não se aplica.

Quem deve ser contactado em caso de urgência?
Não se aplica
Como é assegurada a confidencialidade dos dados?
A publicação dos resultados desta investigação não o identificará como participante neste estudo. Apenas você e os investigadores envolvidos neste estudo terão conhecimento dos dados recolhidos. A entidade patronal terá conhecimento dos resultados gerais do estudo e não individualmente.
O que acontecerá aos dados quando a investigação terminar?
Uma vez concluído o estudo, os dados serão alvo de análise e trabalho tendo em conta os objetivos traçados. Apenas os investigadores e o próprio participante terão acesso aos dados, mantendo-se os mesmos protegidos em base de dados. A entidade patronal terá conhecimento dos resultados gerais do estudo e não individualmente.
Como irão os resultados do estudo ser divulgados e com que finalidades?
A entidade patronal irá receber um relatório sobre os possíveis fatores de risco que causam sintomas músculo-esqueléticos dos seus trabalhadores com computador de forma a proceder a uma intervenção ergonómica e terapêutica no local de trabalho. Existe o objetivo de publicar os resultados do estudo epidemiológico em jornais de referência com revisão por pares e fator de impacto, assim como, a apresentação dos resultados em Congressos / Conferências da especialidade. Defesa pública da dissertação da tese de doutoramento na Faculdade de Motricidade Humana da Universidade de Lisboa.
Em caso de dúvidas quem devo contactar?
Para qualquer questão relacionada com a sua participação neste estudo, por favor, contactar: Alexandre Nunes para o e-mail alexandrempnunes@gmail.com e telefone n. 965726125

Assinatura do Consentimento Informado, Livre e Esclarecido

Li (ou alguém leu para mim) o presente documento e estou consciente do que esperar quanto à minha participação no estudo (NOME DO ESTUDO). Tive a oportunidade de colocar todas as questões e as respostas esclareceram todas as minhas dúvidas. Assim, aceito voluntariamente participar neste estudo. Foi-me dada uma cópia deste documento.

Nome do participante **Assinatura do participante**

Data

Nome do representante legal do participante
(se aplicável)

Grau de relação com o participante

Investigador/Equipa de Investigação

Os aspetos mais importantes deste estudo foram explicados ao participante ou ao seu representante, antes de solicitar a sua assinatura. Uma cópia deste documento ser-lhe-á fornecida.

Nome da pessoa que obtém o consentimento **Assinatura da pessoa que obtém o consentimento**

Data

Appendix V

Online Questionnaire

QUESTIONÁRIO A TRABALHADORES COM COMPUTADOR

Este questionário é realizado no âmbito do Doutoramento em Reabilitação a decorrer na Faculdade de Motricidade Humana – Universidade de Lisboa. Pretendemos obter informações, exclusivamente, para melhorar a forma como trabalha com computador com o objetivo de evitar/melhorar problemas músculo-esqueléticos. Neste sentido o questionário não é **anónimo**, nem **confidencial**.

Seja, POR FAVOR, o mais coerente possível nas suas respostas.

Nas questões de resposta múltipla, assinale com uma cruz o quadrado correspondente à opção correta.

O tempo de preenchimento é cerca de 15 a 20 minutos. Tem a possibilidade de preencher questionário de uma vez só ou progressivamente, desde que este seja preenchido durante o mesmo dia.

MUITO OBRIGADO PELO SEU CONTRIBUTO!

Informação:

Nome ____

E-mail____

Universidade de Lisboa ☐ Universidade do Algarve ☐ Município de Albufeira☐

A – Caracterização geral do trabalho com computador

1. Género: Masculino □ Feminino □
2. Idade: ________________
3. Peso_________ kg
4. Altura?_________ cm
5. Qual o seu membro superior dominante: Dextro □ Esquerdo/Canhoto □ Ambidextro □
6. Há quantos anos e meses é colaborador na empresa?___Anos _________ Meses
7. Horário? Fixo □ Por turnos □
8. Em média, quantas horas trabalha por semana? ____________ horas.
9. Em média, quantas horas trabalha com computador por dia? _________horas.
10. Há quantos anos trabalha com computador:_______ Anos
11. Realiza algum tipo de atividade de lazer ou desportiva no local de trabalho ou fora da empresa?

    Não □ Sim □

    Se sim qual (quais)?___________________________

    Qual a duração média semanal desta(s) atividades?__________ horas
12. Quanto tempo trabalha em média por dia com computador sem interrupção? _______ horas.
13. Quantas pausas curtas (inferiores a 7 minutos) faz durante um dia de trabalho? _________ .
14. Qual o tipo de computador que usa no seu trabalho de secretária?

□ Apenas portátil

□ Mais portátil do que computador de mesa

□ Uso ambos de igual forma

□ Mais computador de mesa do que portátil

□ Apenas computador de mesa

15. Utiliza documentos quando está a trabalhar ao computador?

NÃO □ SIM □, se sim:

□ Na mesa de trabalho ao lado do teclado, seja do lado direito ou esquerdo

□ Na mesa de trabalho, entre o teclado e o monitor

□ Num suporte ao mesmo nível do computador

Indique se tiver outra opção

____

Organização do posto de trabalho e forma como trabalha

B - Questões relacionadas com o monitor

16. Usa mais do que um monitor? Não □ Sim □

Se sim, qual a frequência?

□ Nunca

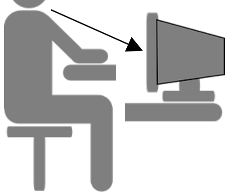
□ Raramente

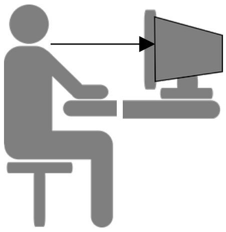
□ Às vezes

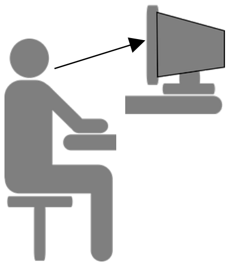
□ Regularmente

□ Sempre

17- Qual a altura do bordo superior do monitor relativamente à linha dos olhos?







Abaixo □ Ao mesmo nível □ Acima □

18. Qual a localização do monitor relativamente à posição de trabalho?

Não se aplica se usa portátil □

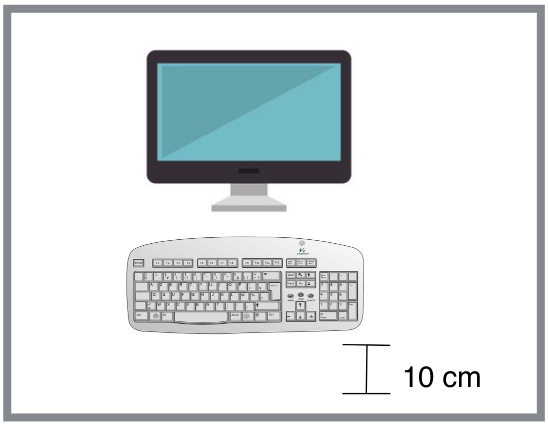
À sua direita □ Em frente □ À sua esquerda □

C - Questões relacionadas com o teclado

19. Qual a altura do teclado relativamente à altura dos cotovelos?

Cotovelos abaixo teclado □ Cotovelos ao mesmo nível □ Cotovelos acima teclado □

20. O teclado está mais de 10 cm à frente do bordo da mesa?



NÃO □ SIM □

21. Apoia o antebraço durante o trabalho com o teclado?

Não apoia □

Apoia os cotovelos na cadeira ☐

Apoia menos de 2/3 do antebraço na mesa de trabalho ☐

Apoia mais de 2/3 do antebraço na mesa de trabalho ☐

22. Utiliza algum tipo de suporte para trabalhar com o teclado?

NÃO □ SIM □ Sim, qual?________________________________

D - Questões relacionadas com o rato (Se não utiliza rato no trabalho com computador passe para as questões do grupo E)

23. Tem espaço suficiente na sua secretária para trabalhar com o rato? NÃO □ SIM □

24. Utiliza algum tipo de suporte para trabalhar com o rato? NÃO □ SIM □

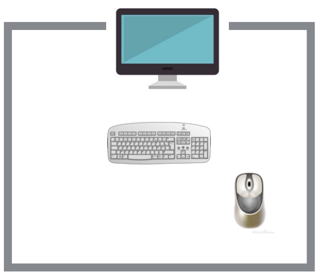
25. Qual é a mão com que trabalha com o rato? DIREITA □ ESQUERDA □

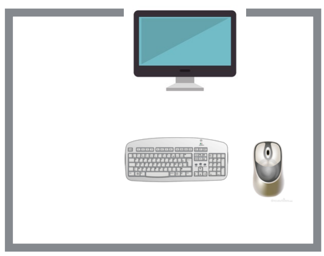
26. Qual a regularidade com que utiliza o rato ao trabalhar no computador?

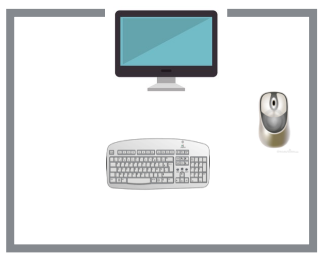
□ Menos de 50% do tempo de trabalho com computador

□ Mais de 50% do tempo de trabalho com computador

27. Qual a localização do rato quando trabalha?







Próximo do bordo mesa □ Ao lado do teclado □ Afastado do teclado mas próximo do monitor □

E - Questões relacionadas com a cadeira do posto de trabalho

28. Como apoia a sua coluna na cadeira?

Lombar □

Lombar e dorsal □

Toda a coluna incluindo cervical □

Outro______________________

29. A sua cadeira é regulável em altura? NÃO □ SIM □

30. A sua cadeira tem apoio de braços? NÃO □ SIM □

31. Quando está sentado usa apoio para os pés? NÃO □ SIM □
Se sim, usa sempre o apoio □ ou alterna com e sem apoio □

32. Quando está sentado qual a sua posição dos joelhos relativamente às ancas?

Joelhos acima das ancas □

Ao mesmo nível □

Joelhos abaixo das ancas

F - Caracterização do Estado de Saúde

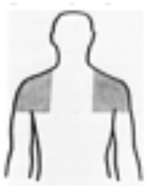
33. Sofre de alguma doença:

	Não	Sim	Qual
Doenças Cardíacas (ex. Angina de Peito)			
Doenças Neurológicas (ex. alguma forma de Paralisia)			
Doenças Endócrinas (ex. Diabetes, Hipotiroidismo)			
Doenças Reumáticas (ex. Artrite Reumatóide)			
Doenças Oncológicas			

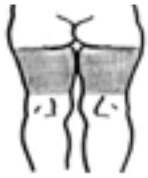
Outra doença não mencionada.____

34. Teve dor, desconforto, ou mal estar com uma duração superior a 30 dias no último ano nas seguintes regiões?

Pescoço ☐



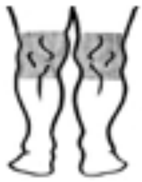
Ombro ☐



Coxa ☐

Zona dorsal ☐

Cotovelo ☐



Joelho ☐

Zona lombar ☐

Cotovelo ☐

Tornozelo e Pé ☐

Se indicou dor ou desconforto na região do PESCOÇO responda às seguintes questões:

35 Qual a intensidade de dor no último ano:

☐ Muito liigeira

☐ Ligeira

☐ Moderada

☐ Intensa

☐ Muito intensa

36 Qual a intensidade de dor nos últimos 7 dias numa escala de 0 a 10, em que 0 é nenhuma dor e 10 é a dor mais forte que já sentiu

Sem Dor	0	1	2	3	4	5	6	7	8	9	10	Dor Máxima

37. Qual a frequência de dor no último mês:

☐ Raramente

☐ 1 vez por semana

☐ Mais que 1 vez por semana

☐ Quase sempre presente

38. Indique se tem ou já teve algum dos seguintes diagnósticos:

Fibromialgia	
Hérnia discal na cervical	
Golpe de chicote na cervical devido a algum episódio traumático	
Fraturas na coluna cervical	
Artrose severa na Cervical	

Appendix VI

Informed consent term for the clinic examination

CONSENTIMENTO INFORMADO LIVRE E ESCLARECIDO

Título do projeto ou estudo:

Nociplastic pain in office workers with chronic neck pain

Pessoa responsável pelo projeto:

Alexandre Maurício Passos Nunes

Instituição de acolhimento:

Faculdade de Motricidade Humana – Universidade de Lisboa

Este documento, designado **Consentimento, Informado, Livre e Esclarecido**, contém informação importante em relação ao estudo para o qual foi abordado/a, bem como o que esperar se decidir participar no mesmo. Leia atentamente toda a informação aqui contida. Deve sentir-se inteiramente livre para colocar qualquer questão, assim como para discutir com terceiros (amigos, familiares) a decisão da sua participação neste estudo.

Informação geral
Está a ser convidado(a) a participar num projeto de investigação no âmbito do Doutoramento em Motricidade Humana na especialidade de Reabilitação, da Faculdade de Motricidade Humana – Universidade de Lisboa (FMH-UL) que pretende estudar e captar informação que ajude não só a melhorar o entendimento do fenómeno da dor que aflige trabalhadores com computadores, do ponto de vista dos clínicos e investigadores, mas que permita, transportar esses conhecimentos para dar resposta em termos de Reabilitação a outros problemas músculo-esqueléticos. A seleção para a participação baseia-se nos critérios de elegibilidade do estudo: adulto (25-60 anos), trabalho com computador pelo menos há mais de um ano e cerca de ¾ do período laboral ao computador. Será realizada um exame clinico com o objetivo de se diagnosticar Mialgia Crónica do Trapézio.
Qual a duração esperada da minha participação?
A sua participação terá uma duração aproximada de 10 minutos.
Quais os procedimentos do estudo em que vou participar?

Será realizada um exame clinico à sua cervical sendo composta por perguntas específicas, mobilidade da cervical e ombro, e palpação da zona dolorosa para se avaliar a existência de pontos gatilho.
A minha participação é voluntária?
A sua participação é voluntária e pode recusar-se a participar. Caso decida participar neste estudo é importante ter conhecimento que pode desistir a qualquer momento, sem qualquer tipo de consequência para si. No caso de decidir abandonar o estudo, a sua relação com a Universidade de Lisboa (UL)/ Jerónimo Martins (JM) não será afetada. Se for o caso, o seu estatuto enquanto funcionário da UL/JM será mantido e não sofrerá nenhuma consequência da sua não-participação ou desistência.
Quais os possíveis benefícios da minha participação?
Fornecer dados sobre a prevalência de mialgia crónica do trapézio em trabalhadores com computador.
Quais os possíveis riscos da minha participação?
A aplicação dos testes ou procedimentos não colocam o participante em qualquer risco.
Quem assume a responsabilidade, no caso de um evento negativo?
A pessoa responsável pelo projeto: Alexandre Nunes.
Há cobertura por uma companhia de seguros?
Não, mas o investigador tem seguro de responsabilidade civil.
Quem deve ser contactado em caso de urgência?
O investigador principal.
Como é assegurada a confidencialidade dos dados?
A publicação dos resultados desta investigação não o identificará como participante neste estudo. Apenas você e os investigadores envolvidos neste estudo terão conhecimento dos dados recolhidos.
O que acontecerá aos dados quando a investigação terminar?

Uma vez concluído o estudo, os dados serão alvo de análise e trabalho tendo em conta os objetivos traçados. Apenas os investigadores e o próprio participante terão acesso aos dados, mantendo-se os mesmos protegidos em base de dados.
Como irão os resultados do estudo ser divulgados e com que finalidades?
Os resultados serão publicados em revistas de referência na área da dor/saúde e qualidade de vida com revisão por pares e fator de impacto. Existe a possibilidade da divulgação dos resultados em Congressos/Conferências da especialidade. Defesa pública e publicação da dissertação da tese de doutoramento na Faculdade de Motricidade Humana da Universidade de Lisboa.
Em caso de dúvidas quem devo contactar?
Para qualquer questão relacionada com a sua participação neste estudo, por favor, contactar: Alexandre Nunes para o e-mail aim.fmh@gmail.com e telefone n. 965726125

Assinatura do Consentimento Informado, Livre e Esclarecido

Li (ou alguém leu para mim) o presente documento e estou consciente do que esperar quanto à minha participação no estudo AIM - **A**valiação e **I**ntervenção na **M**ialgia crónica trapézio em trabalhadores com computadores. Tive a oportunidade de colocar todas as questões e as respostas esclareceram todas as minhas dúvidas. Assim, aceito voluntariamente participar neste estudo. Foi-me dada uma cópia deste documento.

Nome do participante **Assinatura do participante**

Data

Nome do representante legal do participante (se aplicável)

Grau de relação com o participante

Investigador/Equipa de Investigação

Os aspetos mais importantes deste estudo foram explicados ao participante ou ao seu representante, antes de solicitar a sua assinatura. Uma cópia deste documento ser-lhe-á fornecida.

Nome da pessoa que obtém o consentimento	**Assinatura da pessoa que obtém o consentimento**

Appendix VII

Individual clinic examination form

EXAMINAÇÃO CLÍNICA

Nome ____ Data _____/______/______

Idade_____Sexo____Peso______kg Altura_________cm ID___________________

Dor na cervical: Sim Não Dificuldade/dor em fazer movimentos: Sim Não

Dor no ombro: Sim Não Dificuldade/dor em fazer movimentos: Sim Não

Quanto tempo com dor? Anos ______ Meses_________

Nível de dor: Hoje _________ Nos últimos 7 dias _________

☐ Raramente ☐ 1 vez por semana ☐ Mais que 1 vez por semana ☐ Quase sempre presente

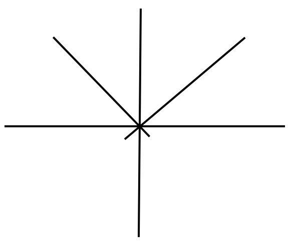
Está a fazer algum tratamento para esta dor? Não Sim Qual___________________

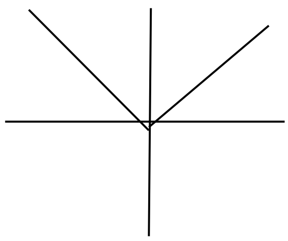
Medicação

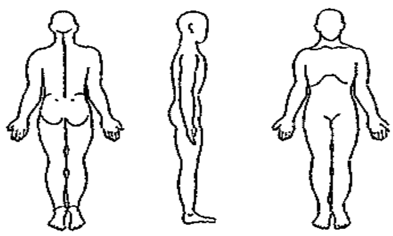
Sintomas Neurológicos:

Dor de cabeça / visão(2x) / ouvidos / desequilíbrios/ fraqueza (geral, distal, proximal) / tonturas / vertigens / parestesias e alteração sensibilidade nos membros superiores

ROM Cervical ROM ombro Localização da dor







Outros Testes:

Critério Inclusão da examinação clínica:

Dor na região da cervical – ombro? Sim Não

Sensação de tensão/rigidez na flexão lateral da cabeça? Sim Não

Palpação de tensão/ rigidez no trapézio superior. Sim Não

Appendix VIII

Informed consent term for data collection

CONSENTIMENTO INFORMADO LIVRE E ESCLARECIDO

Título do projeto ou estudo:

Nociplastic pain in office workers with chronic neck pain.

Pessoa responsável pelo projeto:

Alexandre Maurício Passos Nunes

Instituição de acolhimento:

Faculdade de Motricidade Humana – Universidade de Lisboa

Este documento, designado **Consentimento, Informado, Livre e Esclarecido**, contém informação importante em relação ao estudo para o qual foi abordado/a, bem como o que esperar se decidir participar no mesmo. Leia atentamente toda a informação aqui contida. Deve sentir-se inteiramente livre para colocar qualquer questão, assim como para discutir com terceiros (amigos, familiares) a decisão da sua participação neste estudo.

Informação geral
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Qual a duração esperada da minha participação?

A sua participação terá uma duração aproximada de 50-60 minutos.
Quais os procedimentos do estudo em que vou participar?
As avaliações são procedimentos não invasivos e sem risco para os participantes e serão efetuadas recolhas de algometria, força isométrica de dois músculos da zona escapular (ombro). O nível de limiar de dor (algometria) será mapeado em 2 pontos na região entre a coluna cervical(pescoço) e no ombro, e ainda, em 1 ponto no cotovelo e outro na perna. Será utilizado um algómetro que faz pressão e regista em cada ponto a primeira sensação de dor. Posteriormente, uma das suas mãos será colocada em água fria, e será repetido o mesmo procedimento, mas apenas em um ponto entre a coluna cervical (pescoço) e o ombro. No final, terá que preencher alguns questionários sobre dor, stress e incapacidade. Para testar a força será pedido para fazer dois movimentos específicos com a máxima força: o primeiro será encolher os ombros, o segundo será levantar o braço mas na posição deitado. Para todos os procedimentos descritos anteriormente (exceto os questionários) será necessário expor a coluna cervical (pescoço), ombro, membros superiores, e nos membros inferiores apenas até à zona dos joelhos, sendo se necessário, fornecidos calções.
A minha participação é voluntária?
A sua participação é voluntária e pode recusar-se a participar. Caso decida participar neste estudo é importante ter conhecimento que pode desistir a qualquer momento, sem qualquer tipo de consequência para si..
Quais os possíveis benefícios da minha participação?
Fornecer dados para investigação cientifica sobre dor na coluna cervical (pescoço) que será utilizado no desenvolvimento de novos tratamentos. Receberá uma ficha relatório relativa à forma como trabalha ao computador com o objetivo de melhorar a sua condição dolorosa.
Quais os possíveis riscos da minha participação?
A aplicação dos testes ou procedimentos não colocam o participante em qualquer risco, contudo é provável que após a atividade possa sentir um desconforto e/ou aumento da dor

após a avaliação da força isométrica, sendo considerado aceitável um aumento da dor até o nível 5 numa escala numérica da dor (0 = sem dor, 10 = dor insuportável).
Quem assume a responsabilidade, no caso de um evento negativo?
A pessoa responsável pelo projeto: Alexandre Nunes.
Há cobertura por uma companhia de seguros?
Não, mas o investigador tem seguro de responsabilidade civil.
Quem deve ser contactado em caso de urgência?
O investigador principal.
Como é assegurada a confidencialidade dos dados?
A publicação dos resultados desta investigação não o identificará como participante neste estudo. Apenas você e os investigadores envolvidos neste estudo terão conhecimento dos dados recolhidos.
O que acontecerá aos dados quando a investigação terminar?
Uma vez concluído o estudo, os dados serão alvo de análise e trabalho tendo em conta os objetivos traçados. Apenas os investigadores e o próprio participante terão acesso aos dados, mantendo-se os mesmos protegidos em base de dados.
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Assinatura do Consentimento Informado, Livre e Esclarecido

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Nome do participante **Assinatura do participante**

Data

Nome do representante legal do participante
(se aplicável)

Grau de relação com o participante

Investigador/Equipa de Investigação

Os aspetos mais importantes deste estudo foram explicados ao participante ou ao seu representante, antes de solicitar a sua assinatura. Uma cópia deste documento ser-lhe-á fornecida.

Nome da pessoa que obtém o consentimento **Assinatura da pessoa que obtém o consentimento**

Data

Appendix IX

Data collection form

Nome- ____ Data _____/______/______

Idade_______ Sexo ____ Peso______kg Altura___________cm ID__________________

DOR

Sem Dor	0	1	2	3	4	5	6	7	8	9	10	Dor Máxima

PPT	**Trapézio Superior**					
	Trapézio Bilateral					
	Extensor Pulso					
	Tibial Anterior					
TS	**1º**		**10º**		**Score**	
CPM		**Antes**			**Depois**	
		Tempo			**VAS**	

FORÇA

Trial	**Trapézio Superior**	
	Peak	**T.Peak**
1		
2		
3		

Trial	**Trapézio Inferior**	
	Peak	**P. Peak**
1		
2		
2		

QUESTIONÁRIOS

Neck Disability Index ☐ COPSOQ ☐ Catastrofização da Dor ☐

Appendix X

Neck Disability Index Questionnaire

QUESTIONÁRIO SOBRE OS PROBLEMAS QUOTIDIANOS RELACIONADOS COM DORES NO PESCOÇO

(Versão Portuguesa do NDI)

Este questionário foi concebido para dar informações de como a sua **dor no pescoço** afecta a sua capacidade de agir no dia-a-dia. Por favor, responda a cada secção deste questionário assinalando apenas **UM** dos quadrados que melhor se aplique ao seu caso. Sabemos que pode considerar como aplicáveis a si duas afirmações em cada secção mas, por favor, assinale apenas o **quadrado que descreve melhor** o seu problema.

Nome__________________________________ Data_______________

Secção 1 – Intensidade da dor

□ Neste momento não sinto nenhuma dor.

□ Neste momento a dor é muito fraca.

□ Neste momento a dor é moderada.

□ Neste momento a dor é bastante forte.

□ Neste momento a dor é muito forte.

□ Neste momento a dor é mais forte do que se possa imaginar.

Secção 2 – Cuidados pessoais (lavar-se, vestir-se etc.)

□ Posso tratar de mim normalmente sem causar mais dores.

□ Posso tratar de mim normalmente, mas isso causa-me mais dores.

□ É doloroso tratar de mim próprio e sou lento(a) e cuidadoso(a).

□ Consigo realizar a maior parte dos meus cuidados pessoais, mas preciso de algum auxílio.

□ Na maior parte dos meus cuidados pessoais, preciso todos os dias auxilio.

□ Não consigo vestir-me, lavo-me com dificuldade e permaneço deitado(a) na cama.

Secção 3 – Levantar coisas

□ Consigo levantar coisas pesadas sem causar mais dores.

□ Consigo levantar coisas pesadas mas causa-me mais dores.

□ A dor impede-me de levantar coisas pesadas do chão, mas posso levantá-las se estiverem convenientemente colocadas, como por exemplo em cima de uma mesa.

□ A dor impede-me de levantar coisas pesadas, mas consigo fazê- lo se forem coisas leves ou de peso médio, convenientemente colocadas.

□ Posso levantar apenas coisas muito leves.

□ Não consigo levantar ou transportar seja o que for.

Secção 4 – Leitura

□ Posso ler o tempo que quiser sem causar dores no pescoço.

□ Posso ler o tempo que quiser mas com uma ligeira dor no pescoço.

□ Posso ler o tempo que quiser mas com dores moderadas no pescoço.

□ Não posso ler o tempo que quiser por causa das dores relativamente fortes no pescoço.

□ Quase que não posso ler por causa das dores muito fortes no pescoço.

□ Não posso ler nada por causa das dores no pescoço.

Secção 5 – Dores de cabeça

□ Não tenho qualquer dor de cabeça.

□ Tenho ligeiras dores de cabeça que aparecem de vez em quando.

□ Tenho dores de cabeça moderadas que aparecem de vez em quando.

□ Tenho dores de cabeça moderadas que aparecem frequentemente.

□ Tenho fortes dores de cabeça que aparecem frequentemente.

□ Tenho dores de cabeça quase permanentemente.

Secção 6 – Concentração

□ Consigo concentrar-me sem dificuldade.

□ Consigo concentrar-me, mas com ligeira dificuldade.

□ Sinto alguma dificuldade em concentrar-me.

□ Sinto muita dificuldade em concentrar-me.

□ Sinto imensa dificuldade em concentrar-me.

□ Não sou capaz de me concentrar de todo.

Secção 7 – Trabalho / Actividades diárias

□ Posso trabalhar tanto quanto eu quiser.

□ Só consigo fazer o meu trabalho habitual, mas não mais.

□ Consigo fazer a maior parte do meu trabalho habitual, mas não mais.

□ Não consigo fazer o meu trabalho habitual.

□ Dificilmente faço qualquer trabalho.

□ Não consigo fazer nenhum trabalho.

Secção 8 – Guiar um carro

□ Posso guiar um carro sem causar qualquer dor no pescoço.

□ Posso guiar um carro durante o tempo que quiser, mas com uma ligeira dor no pescoço.

□ Posso guiar um carro durante o tempo que quiser, mas com dores moderadas no pescoço.

□ Não posso guiar um carro durante o tempo que quiser devido a dores relativamente fortes no pescoço.

□ Mal posso guiar um carro devido às dores muitos fortes no pescoço.

□ Não posso guiar um carro por causa das dores no pescoço.

Secção 9 – Dormir

□ Não tenho dificuldade em dormir.

□ O meu sono é ligeiramente perturbado (fico sem dormir no máximo 1 hora)

□ O meu sono é um bocado perturbado (fico sem dormir entre 1 a 2 horas)

□ O meu sono é moderadamente perturbado (fico sem dormir entre 2 a 3 horas)

□ O meu sono é muito perturbado (fico sem dormir entre 3 a 5 horas)

□ O meu sono é completamente perturbado (fico sem dormir entre 5 a 7 horas)

Secção 10 – Actividades de lazer

□ Sou capaz de fazer qualquer das minhas actividades de lazer, sem sentir quaisquer dores no pescoço.

□ Sou capaz de fazer qualquer das minhas actividades de lazer, mas com algumas dores no pescoço.

□ Sou capaz de fazer a maior parte das minhas actividades de lazer, mas não todas, devido às dores no pescoço.

□ Sou capaz de fazer apenas algumas das minhas actividades de lazer habituais devido às dores no pescoço.

□ Dificilmente sou capaz de fazer quaisquer actividades de lazer devido às dores no pescoço.

□ Não sou capaz de fazer nenhuma das minhas actividades de lazer.

Appendix XI

Pain Catastrophizing Scale

ESCALA – PCS

Nome___________________________________ N.º _______________

Toda a gente passa por situações de dor em certos momentos da sua vida. Estas experiência podem incluir dores de cabeça, dores de dentes, dores articulares ou dores musculares. As pessoas estão muitas vezes expostas a situações que podem causar dor, tais como doenças, ferimentos, intervenções de dentistas ou cirurgias.

Queremos conhecer os pensamentos e sentimentos que tem quando está a sentir dores. Em baixo encontra-se uma lista com trezes afirmações que descrevem diferentes pensamentos e sentimentos que podem estar associador à dor. Usando a escala seguinte, por favor indique em que medida tem estes pensamentos e sentimentos quando está com dores

O – Nunca; 1 – Ligeiramente; 2 – Moderadamente; 3 – Bastante; 4 – Sempre

Quando estou com dores....

1	Estou constantemente preocupado(a) em saber se a dor terá fim.	
2	Sinto que não consigo continuar.	
3	É terrível e penso que nunca mais vai melhorar.	
4	É horrível e sento que me ultrapassa completamente.	
5	Sinto que já não aguento mais.	
6	Fico com medo que a dor piores.	
7	Estou sempre a pensar noutras situações dolorosas.	
8	Quero ansiosamente que a dor desapareça.	
9	Não consigo deixar de pensar nisso.	
10	Estou sempre a pensar no quanto dói.	
11	Estou sempre a pensar que quero muito que a dor passe.	
12	Não há nada que eu possa fazer para reduzir a intensidade da dor.	
13	Pergunto-me se poderá acontecer algo grave.	

Versão portuguesa do Pain Catastrophizing Scale. Tradução, adaptação cultural e validação da responsabilidade da Faculdade de Medicina da Universidade do Porto, com a autorização do autor Michael JL Sullivan, PhD.

Appendix XII

Copenhagen Psychosocial Questionnaire II

Nome____ Nº _______________

Com que frequência durante as últimas 4 semanas sentiu.....

1 - Nunca/quase nunca 2- Raramente 3 – Às vezes 4 – Frequentemente 5 – Sempre

	1	2	3	4	5
1 – Dificuldade em adormecer?					
2 – Dormiu mal e de forma sobressaltada					
3 – Acordou demasiado cedo e depois teve dificuldade em adormecer novamente?					
4 – Acordou várias vezes durante a noite e depois não conseguiaadormecer novamente?					
5 – Cansado?					
6 – Esgotado?					
7 – Fisicamente exausto?					
8 – Emocionalmente exausto?					
9 – Dificuldades em relaxar?					
10 – Irritado?					
11 – Tenso?					
12 – Ansioso?					
13 – Triste ?					
14 – Falta de auto-confiança?					
15 – Peso na consciência ou sentimento de culpa?					
16 – Falta de interesse por coisas quotidianas?					
17 – Dores de barriga?					
18 – Aperto ou dor no peito?					
19 – Dores de cabeça?					
20 – Palpitações?					
21 – Tensão em vários músculos?					
22 – Dificuldade em concentrar-se?					
23 – Dificuldade em tomar decisões?					
24 – Dificuldade em lembrar-se de algo?					
25 – Dificuldade em pensar claramente?					

Appendix XIII

Upper and lower trapezius muscle strength in male office workers

Table 1 - Descriptive characteristics of male office workers

Variable	Chronic non-specific neck pain (n=12)	Controls (n=23)	*P*
Age (years)	43.8 ± 8.0	40.2 ± 7.7	.205
Weight (kg)	85.9 ± 12.4	78.5 ± 14.0	.139
Height (cm)	181.5 ± 9.3	174.2 ± 7.7	**.020**
Working hours (/week)	38.5 ± 5.0	37.8 ± 6.5	.722
Working hours on Computer (/day)	6.8 ± 2.1	6.4 ± 1.3	.533
Nº years working with computer	17.1 ± 6.9	17.4 ± 6.2	.866
Physical Activities (UL) ***n*** **(%) yes/no**	3 (25.0%)/ 9 (75.0%)	10 (43.4%) / 13 (56.5%)	.283
Physical Activity (h/week)	3.2± 3.54	3.7± 3.3	.688

Table 2 – Male office workers strength descriptive statistics

Variable	Chronic non-specific neck pain (n=12)		Controls (n=23)		Test Statistic
	M (SD)	95% CI	M (SD)	95% CI	
Strength UT (N)	.327 (.85)	[.273, .382]	.383 (.101)	[.339, .426]	*t* = 1.615
Strength LT (N)	.071 (.021)[a]	[.057, .085]	.094 (.030)	[.081, .107]	*t* = 2.309
Time Peak UT (s)	4.37 (.48)	[4.07, 4.68]	4.47 (.60)	[4.21, 4.73]	*t =-.465*
Time Peak LT (s)	4.41 (.49)	[4.09, 4.73]	4.39 (.52)	[4.16, 4.61]	*t =.116*
Ratio UT/LT	4.92 (1.74)	[3.81, 6.03]	4.43 (1.87)	[3.62, 5.24]	*t =.752*

Abbreviations: LT, lower trapezius; N, newton; UT, upper trapezius.

Figure 1 – Male office workers strength between chronic non-specific neck pain and controls; [a] CNP with CON, *t* test, LT (p=.027)