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Association of Pain extent with Pain intensity, Disability and Headache frequency in Office workers with Neck pain and Headache undergoing Physiotherapy: A secondary analysis

Associação da Extensão da Dor com Incapacidade, Intensidade e Frequência da Dor em Trabalhadores de Escritório com cervicalgia e cefaleia submetidos a intervenção de Fisioterapia: Análise secundária

Dissertação de Mestrado em Fisioterapia
Relatório de Projeto de Investigação

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Relatório de Investigação apresentado para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Fisioterapia, área de especialização em Fisioterapia em Condições Músculo-Esqueléticas realizada sob a orientação científica da Professora Doutora Lúcia Domingues, do Instituto Politécnico de Setúbal, e co-orientação do Mestre Markus Ernst, da Universidade de Ciências Aplicadas de Zurique.

Declaro que este Relatório de Investigação é o resultado da minha investigação pessoal e independente. O seu conteúdo é original e todas as fontes consultadas estão devidamente mencionadas no texto, nas notas e na bibliografia.

A candidata,

Mariya Marchenko

Setúbal, 27 de Novembro de 2024

Declaro que este Relatório de Investigação se encontra em condições de ser apresentada a provas públicas.

A orientadora,

Lúcia Domingues

Setúbal, 28 de Novembro de 2024

To my parents,

for making this path possible

and always believing in me.

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RESUMO

Associação da Extensão da Dor com Incapacidade, Intensidade e Frequência da Dor em Trabalhadores de Escritório com Cervicalgia e Cefaleia submetidos a Intervenção de Fisioterapia: Análise secundária

Mariya Marchenko; Markus Ernst; Lúcia Domingues

Palavras-chave: Pain drawings; Extensão da dor; Cervicalgia; Cefaleia; Trabalhadores de escritório; Intensidade da dor; Incapacidade; Frequência das cefaleias

Introdução: Cervicalgia e cefaleia são comuns em trabalhadores de escritório (TE) e levam a um encargo significativo a nível pessoal, social e económico. A Extensão de dor (ED), obtida através de *pain drawings* (PDs), pode estar associada com outros outcomes clínicos. Porém, a associação entre a ED e outros outcomes, assim como a associação entre a *evolução* na ED e a *evolução* em outros outcomes, não foram estudadas nesta população. **Objetivo:** Descrever 1) as mudanças na ED, intensidade da dor cervical, incapacidade e frequência das cefaleias; estudar 2) a associação entre a ED e os restantes outcomes; e 3) a associação entre a *evolução* na ED e a *evolução* nestes outcomes, em TE com cervicalgia e/ou cefaleia. **Metodologia:** Foi realizada uma análise secundária com 112 participantes, que foram divididos em três grupos consoante a localização da dor. Os outcomes considerados foram a intensidade da dor cervical (END), incapacidade (NDI e HIT-6) e frequência das cefaleias. Foram considerados dois momentos de avaliação - baseline e follow-up. As correlações foram calculadas para cada grupo, através do teste de correlação de Spearman. **Resultados:** A intensidade da dor cervical permaneceu relativamente estável ao longo do tempo. As restantes variáveis melhoraram ao longo do tempo, excepto a ED no grupo com cervicalgia. Não foram encontradas associações para TE com cervicalgia. Em TE com cervicalgia e cefaleia, uma maior ED parece estar associada com maiores níveis de incapacidade (NDI) e frequência das cefaleias, em ambos os momentos. No follow-up, uma maior ED parece estar associada com maior intensidade de dor cervical e maiores níveis de incapacidade (HIT-6). A evolução na ED demonstrou estar associada com a evolução da dor cervical e com os níveis de incapacidade (NDI). Em TE com cefaleia, uma maior ED parece estar associada com maiores níveis de incapacidade (HIT-6) e frequência das cefaleias, mas apenas no follow-up. **Conclusão:** O benefício do uso de PDs parece ser limitado em condições que afetam pequenas áreas (cervicalgia, cefaleia). Em TE com cervicalgia e cefaleia, os PDs podem ser um complemento valioso a outros outcomes clínicos, melhorando a profundidade e precisão da avaliação.

ABSTRACT

Association of Pain extent with Pain Intensity, Disability and Headache frequency in Office workers with Neck pain and Headache undergoing Physiotherapy: A secondary analysis

Mariya Marchenko; Markus Ernst; Lúcia Domingues

Keywords: Pain Drawings; Pain Extent; Neck Pain; Headache; Office Workers; Pain Intensity; Disability; Headache Frequency

Introduction: Neck pain and headache are common among office workers (OW) and lead to a significant personal, societal and economic burden. Pain extent (PE) obtained from pain drawings (PDs) can be associated with other clinical outcomes. However, the association between PE and other outcome variables, as well as the association between *changes* in PE and *changes* in other outcome variables is unknown in this population. **Objective:** To describe 1) the changes in PE, neck pain intensity, disability and headache frequency; to study 2) the association between PE and the other outcomes; and 3) the association between *changes* in PE and *changes* in these variables, in OW with neck pain and/or headache. **Methodology:** A secondary analysis with 112 participants was conducted. Participants were divided into three groups considering their pain location. The outcome measures were neck pain intensity (NRS), disability (NDI and HIT-6) and headache frequency. Two time points were considered, baseline and follow-up. Correlations between PE and other outcome variables were calculated for each group, using Spearman's correlation coefficient. **Results:** Neck pain intensity remained relativelly stable over time. All other variables improved over time, except PE in the 'headache group'. No associations were found for OW with isolated neck pain. In office workers with neck pain and headache, a larger PE was associated with higher NDI scores and headache frequency, at both time points. At follow-up, a larger PE was associated with higher neck pain intensity and higher HIT-6 scores. A *change* in PE was positively associated with a *change* in neck pain intensity and in NDI scores. For OW with isolated headaches, a larger PE was associated with higher HIT-6 scores and headache frequency, but only at follow-up. **Conclusion:** The utility of PDs seems to be limited in conditions with smaller pain areas (isolated neck pain, isolated headache). In OW with neck pain and headache, PDs could be a valuable complement to other clinical and patient-reported outcomes, by enhancing the depth and precision of the assessment.

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LIST OF ABBREVIATIONS

DALYs - Disability-adjusted life-years

END - Escala Numérica da Dor

HIT-6 - Headache Impact Test questionnaire

NDI - Neck Disability Index questionnaire

NRS - Numeric Rating Scale

PDs - Pain Drawings

PE - Pain Extent

TTH - tension-type headache

VAS - Visual analog scale

YLDs - Years lived with disability

1. Introduction

Pain is a complex and subjective experience that varies widely among individuals, influenced by physical, psychological, social and environmental factors (Carriere et al., 2020; Emerson et al., 2023; Kristoffersen et al., 2019; Spink et al., 2021; Watson et al., 2019). Work-related musculoskeletal disorders are a constellation of painful disorders of muscles, tendons, joints and nerves which can affect all body parts, although the neck is among the most affected areas (Van Eerd et al., 2016). In Europe, upper extremity musculoskeletal disorders are considered an increasing health problem, with significant financial costs due to the high amount of disability claims and lost productivity in many economic sectors worldwide, including office workers (Aegerter et al., 2023; Van Eerd et al., 2016).

Neck pain and headaches are among the most frequently reported complaints by office workers (Aegerter et al., 2023; Magnavita, 2022). It is estimated that 68% of Swiss office workers experience at least one day per year with non-specific neck pain (Amstutz et al., 2010, as cited in Aegerter et al., 2023). Working with a computer for prolonged periods of time in sustained postures, lack of physical activity and perceived stress are considered risk factors for neck pain and headaches, which is reflected in the high prevalence of these conditions among office workers (Ernst et al., 2023; Kazeminasab et al., 2022; Magnavita, 2022; Rodrigues et al., 2017).

Neck pain is a multifactorial disorder that leads to significant job absences and a remarkable economic and societal burden (Aegerter et al., 2023; Kazeminasab et al., 2022; Macdermid et al., 2009). The global age-standardized prevalence rate of neck pain was estimated to be 2450 per 100.000 population in 2020 and the age-standardized incidence rate of neck pain in Central Europe in 2019 was 348 per 100.000 (Li et al., 2023; Wu et al., 2024). A study on a representative Zurich-based population, among young and middle-aged adults, reported a neck pain prevalence between 18-55% (Amstutz et al., 2010, as cited in Aegerter et al., 2020).

Moreover, neck pain has recurrence rates as high as 50-75% in the first five years, with 19% of the population at risk of suffering from chronic neck pain at any given time (Carroll et al., 2008, as cited in Aegerter et al., 2023; Macdermid et al., 2009). In the *Global Burden of Disease Study 2019*, neck pain was among the top ranked causes of Disability-adjusted life-years (DALYs) (Vos et al., 2020).

Neck pain and headaches are commonly present together which can be related to a cervical musculoskeletal dysfunction, or the neck pain can be part of the headache symptomatology (e.g migraine, tension-type, cervicogenic headache) (Ashina et al., 2015; Delen & İlter, 2023; Ernst et al., 2023; Jull, 2023; Matharu et al., 2024). Both neck pain and headaches have a high impact on quality of life and disability at the individual level, and lead to huge financial costs at a societal level (Aegerter et al., 2023; Magnavita, 2022; Steiner et al., 2014). In the past 20 years, efforts have been made to reduce the burden of headache disorders, as they are the second leading cause of years lived with disability (YLDs) in adults and cause significant personal, societal and economical burdens (Magnavita, 2022; Saylor & Steiner, 2018; Wu et al., 2024).

Headache disorders affect approximately 90% of people during their lifetime (Magnavita, 2022). A cross-sectional study found a one-year prevalence of headache disorders to be as high as 79% (Saylor & Steiner, 2018). The two most common headache types among the participants of this study were migraines and tension-type, and they have an estimated global prevalence of 12-14.7% and 20-38% respectively; being leading causes of disability worldwide (Magnavita, 2022; Steiner et al., 2014; Stovner et al., 2018; Uthaikhup et al., 2020).

In a Swiss survey of over 1200 office workers, 35% reported at least one headache episode within the previous four weeks (Amstutz et al., 2010, as cited in Aegerter et al., 2023). Headaches significantly affect sleep quality, work, family life, social activities, mood, the ability to carry out daily activities and quality of life in general (Leiper et al., 2006; Magnavita, 2022; Matharu et al., 2024; Mingels et al., 2021). Headache disorders not only significantly reduce the quality of life but also create an economic burden due to the associated absenteeism and presenteeism, that in the long-term lead to a significant decrease in productivity (Aegerter et al., 2023; Magnavita, 2022).

The impact of neck pain and headaches calls for intervention in the workplace (Magnavita, 2022). Evidence-based prevention and management of neck pain and headache conditions include neck strengthening exercises and best-practice ergonomics (Aas, Tuntland, et al., 2011; Pereira et al., 2019; Van Eerd et al., 2016 as cited in Aegerter et al., 2023; Altmis Kacar et al., 2024; Basakci Calik et al., 2020; Johnston et al., 2021; Magnavita, 2022; Martín-Vera et al., 2023; Priya et al., 2022; Rinne et al., 2023; Rodrigues et al., 2017; Svensson et al., 2024). To monitor the effects of evidence-based care, justify services, evaluate programs, guide clinical decision-making and use in research, it is imperative to monitor clinical outcomes (Macdermid et al., 2009; Young et al., 2019). It is equally important to use outcomes that are reliable, valid, responsive and condition specific (Macdermid et al., 2009; Young et al., 2019).

For patients with neck pain, the Numeric Rating Scale (NRS) and the Neck Disability Index (NDI) are considered reliable, valid and responsive self-report outcomes; and their psychometric properties have been established (Cleland et al., 2008; Macdermid et al., 2009; Vernon, 2008; Young et al., 2019). For people with headaches, the clinical guidelines recommend assessing outcomes such as headache frequency and disability. These outcomes can be measured directly, like headache frequency, or through questionnaires like the Headache Impact Test (HIT-6) for disability (Becker et al., 2015; Bini et al., 2022; Demarquay et al., 2021; Kaniecki, 2003; Niere & Jerak, 2004; Stewart et al., 2002).

Accurately assessing pain remains a significant challenge in clinical practice, as it involves capturing more than just the intensity of pain (Carriere et al., 2020; Emerson et al., 2023; Kristoffersen et al., 2019; Spink et al., 2021; Watson et al., 2019). When examining a patient with pain, characteristics such as location, extension and distribution of pain may also be regarded (Barbero et al., 2020). Pain drawings (PDs) have been used as a screening tool for decades, in varied contexts and with varied objectives (Grunnesjö et al., 2006). PDs are used to describe the individual's complex pain experience through a relatively simple graphical representation of pain location and distribution, through which pain extent (PE) can be calculated (Fernández-De-Las-Peñas et al., 2018; Grunnesjö et al., 2006; Palacios-Ceña et al., 2017; Uthaikhup et al., 2024).

PDs help to precisely quantify the symptomatic area, as well as better describe people's pain experience objectively, with good-to-excellent reliability for patients' self-report of pain location (Barbero et al., 2020; Palacios-Ceña et al., 2017). They can be used to achieve a more comprehensive examination, such as monitoring the clinical evolution of symptoms during the course of a disease, after a treatment intervention, or as a potential prognostic factor for clinical outcomes (Barbero et al., 2020).

There has been an increasing number of studies on PE in the last decades, where the need for investigation of innovative methods to calculate pain drawings-derived measures through digital technology has been reported. Thereafter, software-based PDs analysis has been developed (Barbero et al., 2020; Boudreau et al., 2018; Reis et al., 2019). The calculation of PE by software-based computation allows to provide an accurate topographic distribution of the patient's symptoms, which is a meaningful advancement compared to previously available tools (Barbero et al., 2020; Falla et al., 2016). Moreover, by providing a graphical representation of pain location and distribution, PDs enable healthcare professionals to better understand the complex, individualized nature of a patient's pain, which can inform more personalized treatment strategies (Barbero et al., 2020; Carriere et al., 2020; Emerson et al., 2023; Kristoffersen et al., 2019; Spink et al., 2021; Uthaikhup et al., 2020; Watson et al., 2019).

Even though pain intensity is a widely used outcome measure, pain perception goes beyond external nociceptive input, especially in chronic pain (Barbero et al., 2020; Carriere et al., 2020; Emerson et al., 2023; Kristoffersen et al., 2019; Spink et al., 2021; Uthaikhup et al., 2024; Watson et al., 2019). There is a need for a more comprehensive and multidimensional pain assessment, such as adding PDs to the usual pain intensity assessment, to encompass the various aspects of a patient's pain experience (Barbero et al., 2020; Palacios-Ceña et al., 2017; Uthaikhup et al., 2024). PDs have been a topic of interest in research for several decades, increasingly so in the past years and they have been used for different musculoskeletal disorders, including spine-related disorders such as low back pain and also neck pain (Barbero et al., 2020; Boudreau et al., 2018; Falla et al., 2016; Uthaikhup et al., 2024).

Grunnesjö et al. (2006) conducted a randomized controlled trial on low back pain, with the objective of describing "the course of PDs during treatment in primary health care for low back pain patients". The authors studied 160 primary health care outpatients with acute or sub-acute low back pain for ten weeks. The patients filled out three PDs each and reported pain and functional variables, at baseline and after five and ten weeks of treatment. A strong correlation between PE and pain intensity during the previous week, as well as the Disability Rating Index was reported (Grunnesjö et al., 2006).

Falla et al. (2016) evaluated the relationship between PE and several variables (incl. perceived pain and disability) in a cohort of individuals with chronic whiplash-associated disorder. A total of 205 individuals were included in the observational study, that formed part of a sample of patients included in a randomized controlled trial. The authors accounted for control variables (age, sex, education, insurance status, financial status and pain intensity) and found a statistically significant association between PE and the NDI score ($p<0.01$). More explicitly, a 1-point increase in PE was associated with an average increase of 0.304 points on the NDI (95% CI: 0.102–0.506).

Regarding chronic neck pain, Ris et al. (2019) conducted an observational cross-sectional study, as a secondary analysis of baseline data from a randomized trial. The objective was to evaluate associations between PE and self-reported and measured neck function, among other outcomes. A total of 200 participants were divided into groups by traumatic (n=120) and non-traumatic (n=80) origin. A correlation between PE and patient-reported neck function and muscle test performance was observed. Of special interest for the present study, a moderate correlation ($r=0.45$, $p<0.001$) between PE and NDI was reported in the non-traumatic onset group, and a weak correlation ($r=0.22$, $p=0.02$) in those with trauma-induced chronic neck pain. The authors concluded that patients with larger PE present poorer physical functions and that PDs can indicate a need for addressing these functions in management of a person with chronic neck pain (Ris et al., 2019).

Recently, Uthaikhup et al. (2024) investigated the changes in PE after intervention and its concordance with pain intensity (VAS) and patient-reported outcomes (e.g. NDI) in people with chronic neck pain, which has not been investigated so far. The secondary analysis of a randomized controlled trial analyzed the data of 152 participants. The outcomes were measured at baseline, post-treatment (six weeks later), and at 3-,6- and 12-month follow-ups. No agreement was found between PE and pain intensity, nor between PE and disability immediately post-treatment ($p>0.05$). The levels of agreement between the PE and pain intensity were good at 3-month follow-up (adjusted kappa=0.66; agreement=82.9%) and moderate at 6- and 12-month follow-ups (adjusted kappa=0.54-0.56; agreement=77.0-78.3%). The levels of agreement between pain extent and disability were moderate at 3-, 6-

and 12-month follow-ups (adjusted kappa=0.47-0.58; agreement=73.7-79.0%) (Uthaikhup et al., 2024). The authors reported a modest concordance between the clinical improvement in PE and pain intensity and disability, higher for pain intensity than disability. There was no concordance found between PE and functional ability and health-related quality of life over time. Some people, however, had a discordant response at each follow-up time point (baseline, post-treatment, 3-, 6-, and 12-month follow-ups) (Uthaikhup et al., 2024).

A scoping review was conducted by Barbero et al. (2020), with the aim of mapping current literature and investigating the relationship of PE extracted from PDs with clinical, psychological, and psycho-physiological patient-reported outcome measures in people with pain. There was heterogeneity in the results depending on the pain condition. A larger PE was significantly associated with a higher pain intensity and with a greater disability in individuals with mechanical, traumatic (e.g. whiplash-associated), and work-related neck pain. When it comes to headache, despite some isolated associations, in general, no relationship was observed between PE and clinical, psychological or psycho-physical outcomes in women with chronic tension-type headache or episodic migraine (Barbero et al., 2020).

Uthaikhup et al. (2020) conducted a cross-sectional, observational study with 390 participants recruited from a headache clinic, with the aim of evaluating and comparing the location and extent of pain in different headache types and examine the association between the extent of pain and clinical features (headache features, quality of life, and psychological distress). The authors evaluated people with episodic migraine, chronic migraine, and cervicogenic headache. Considering the association of PE with clinical features, for episodic migraine, there was no association found between PE and clinical features (pain intensity, duration and frequency) ($p>0.05$); whereas in people with chronic migraine, there was a moderate correlation found between larger PE and higher headache intensity ($r_s=0.53$; $p=0.003$) and poorer quality of life assessed by the *36-Item Short Form Health Survey* ($r_s=-0.36$; $p=0.049$) (Uthaikhup et al., 2020).

Succinctly, recent studies have confirmed that PE is associated with clinical outcomes such as pain intensity and related disability, in some musculoskeletal conditions. Larger PE is associated with higher pain intensity and greater disability in mechanical, work-related, and whiplash-associated neck-pain (Barbero et al., 2020; Falla et al., 2016; Ris et al., 2019a;

Uthaikhup et al., 2024). As for headache conditions, associations between PE and clinical features have been reported for chronic migraine, but not for episodic migraine or chronic tension-type headache (Uthaikhup et al., 2020).

Considering the previous literature, there is a need for a deeper understanding of the relationship between PDs and commonly used clinical outcomes. To date, this relationship has not been thoroughly investigated in office workers experiencing neck pain, headache, or both (Barbero et al., 2020; Palacios-Ceña et al., 2017; Uthaikhup et al., 2024). Existing research is limited, often conducted on disparate conditions, with varying objectives, and, in some cases, producing conflicting results (Barbero et al., 2020; Falla et al., 2016; Fernández-De-Las-Peñas et al., 2018; Grunnesjö et al., 2006; Palacios-Ceña et al., 2017; Ris et al., 2019a; Uthaikhup et al., 2024). Most of the studies have been conducted in chronic neck pain and chronic headache conditions, which involve central sensitization. However, based on the available literature, a potential association between PE and other outcomes of sensitization cannot be excluded (Barbero et al., 2020). Additionally, the reported associations appear to be influenced by the specific condition and the time point of assessment, demonstrating inconsistency across different time frames (Uthaikhup et al., 2024).

Thus, the utility of PDs in assessing clinical changes in neck and head-related conditions remains unexplored, even though the need for studies that capture the change in pain presentation over time has been reported (Boudreau et al., 2018). To the best of our knowledge, only one study has examined the concordance for clinical improvement between PE, pain intensity, and patient-reported outcomes in individuals with chronic neck pain. However, no studies have addressed these associations in office workers with neck pain, headache, or both (Uthaikhup et al., 2024). This gap highlights the relevance and the need to advance knowledge in this area.

Therefore, this study aims to contribute to a better understanding of the role of PE in this specific population by addressing key gaps in the literature. Specifically, this study was focused on office workers with neck pain and/or headache, who underwent a neck strength and endurance exercise program combined with health-promotion information and workplace ergonomics (NEXpro). In this context, the comprehensive objectives of this study are as follows:

1) to <u>describe</u> the clinical changes in PE, neck pain intensity (NRS), disability (NDI, HIT-6) and headache frequency (days/month), between baseline and follow-up.

2) to investigate the <u>associations</u> between PE and clinical outcomes (neck pain intensity, disability and headache frequency), at baseline and follow-up.

3) to analyze the <u>associations between changes</u> in PE and changes in neck pain intensity (NRS), disability (NDI, HIT-6) and headache frequency (days/month), from baseline to follow-up.

2. Methodology

2.1 Study design

This study is a secondary analysis of a stepped-wedge cluster randomized controlled trial conducted by Aegerter et al. (2023) from 2020 to 2021, title: "A Multi-component Intervention (NEXpro) Reduces Neck Pain-Related Work Productivity Loss: A Randomized Controlled Trial Among Swiss Office Workers".

Considering the proposed objective of the present study, conducting a secondary analysis is an appropriate and viable approach. It allows to formulate hypothesis and conduct an exploratory analysis by creating groups from previously collected data (Bonita, Beaglehole, & Kjellstrom, 2010; Edwards, Chepeha, Jones, Sheps, & Beaupré, 2020; Horn, George, Li, Luo, & Lentz, 2021; Krauss, Hein, Steinhilber, & Janßen, 2020; Willaert et al., 2020). Secondary data analysis offers several advantages, including the ability to address clinically relevant questions without the significant time and financial investment required for a primary study. It leverages a large existing dataset, avoiding unnecessary repetition of research on the same population (Sun & Lipsitz, 2018; Trinh, 2018; Wickham, 2019; Windle, 2010). The original study investigated work productivity loss among office workers with neck pain, headache, or both; or who were interested in preventing them; while this secondary analysis focuses on the relationship of PE with pain intensity, disability and headache frequency in the head and neck region.

In the original trial, all participants were offered a neck strength and endurance exercise program combined with health-promotion information and workplace ergonomics (Aegerter et al., 2023). To answer the research question of the present study (secondary analysis), the participants of the original study will be classified into three subgroups based on their pain location at baseline: (1) participants with neck pain only, (2) participants with both neck pain and headache, and (3) participants with headache only. Participants without pain in the neck or head region will be excluded from this secondary analysis.

2.2 Participants

The considered target population were office workers in Switzerland with neck pain, headache or both at the start of the study. In the scope of this study, a part of the sample from the primary study was used, in line with the established objective. The eligibility of the participants included in this secondary analysis was guaranteed by meeting all the inclusion criteria and none of the exclusion criteria being verified. In the scope of the present study, all participants met the following inclusion criteria: being an adult aged between 18 and 65 years; working more than 25h per week in a predominantly sitting position; suffering from neck pain, headache or both; being able to communicate in German; and having given a written informed consent (Aegerter et al., 2023).

None of the exclusion criteria was verified in the participants, which as stated by Aegerter et al. (2023) were the following: "previous trauma or injury to the neck (e.g., neck pain grade 4), specific diagnosed pathology of the neck (e.g., fracture), inflammatory disease of the neck (e.g., spondyloarthropathies), or previous neck surgery; participants who had planned an absence longer than 4 weeks during the intervention; pregnant women and participants with known contraindications to performing neck exercises (e.g., on medical advice)". In the scope of this study, in line with the research question for the secondary analysis, the following exclusion criteria was added: not having neck pain, nor headache.

In the original study, all participants were offered a 12-week intervention consisting of a workstation ergonomics intervention, weekly group health-promotion information workshops, and neck exercises. The ergonomics intervention lasted 30-min and covered the positioning and adjustment of the monitor, desk and chair. Participants were asked to follow these recommendations throughout the intervention period (Aegerter et al., 2023). Health promotion workshops had a 45-min duration and the participants were asked to attend at least 8 of the 12 workshops, which covered the following topics: "anatomy of the musculoskeletal system, goal setting, exercise and health, self-efficacy, work stress, digital media and ergonomics, mental health, conflict management, relaxation and sleep, nutrition, resilience and mindfulness, and maintaining motivation" (Aegerter et al., 2023). Participants were instructed to perform neck exercises for 20 min at least three times per week during working hours, one of them supervised. The program consisted of 16 exercises targeted to the neck and upper body, the load defined at 10-repetition-maximum (10-RM), with two to three sets of 10-15 repetitions. Interventions were delivered by physiotherapists, movement scientists, and/or Master of Psychology students, later mentioned for health promotion interventions only, who were trained for at least four hours prior to the intervention (Aegerter et al., 2023).

Recruitment took place from October to December 2019 in two government-funded Swiss organizations: one in the higher education sector in Winterthur and the other one in the service sector in Aarau. Employees were informed by e-mail, intranet and during lunch meetings. Those who were interested in participating could register on a website and were contacted by phone and screened for inclusion and exclusion criteria. Further details on the recruitment process and intervention can be found on the primary study publication - "A Multi-component Intervention (NEXpro) Reduces Neck Pain-Related Work Productivity Loss: A Randomized Controlled Trial Among Swiss Office Workers" (Aegerter et al., 2023).

2.3 Outcome measures

The outcomes considered for this study were: pain extent (PE), pain intensity, disability and headache frequency (Aegerter et al., 2023; Barbero et al., 2020; Blanpied et al., 2017; Gago-Veiga et al., 2021; Lemeunier et al., 2019; Uthaikhup et al., 2024). To define the participant's groups, the clinical questionnaire completed at baseline was considered, where participants were asked whether they have had neck pain or headache in the previous 4 weeks (Yes/No). If they answered yes, they were allocated to the respective group, based on the location of their pain.

2.3.1 Pain extent

Pain Drawings (PDs) were used to measure the Pain extent (Appendix 2). To calculate the Pain extent, after the participants had drawn on a body chart where they had experienced pain during the previous week, the PDs were scanned with a colour scanner, rotated and scaled to match the size and orientation of the original body chart (usually 1024 × 768 pixels) (Figure 1). The number of coloured pixels inside the body chart was calculated through a software to obtain the PE (Figure 2) (Barbero et al., 2020).

The use of PDs has been shown to be reliable (Barbero et al., 2020; Leoni et al., 2017; Margolis et al., 1986; Uthaikhup et al., 2024). The test-retest reliability of PDs was high with reported values of ICC = 0.98 (95% CI:0.96–0.99), and pain location reliability was examined using Jaccard similarity coefficient (JSC) with a reported median JSC = 0.73 (0.64;0.80) (Leoni et al., 2017). Six areas were considered: 1) front neck; 2) back neck; 3) front left head; 4) front right head; 5) back left head; and 6) back right head. In the scope of this study, to calculate the total area of PE, the head and neck areas were summed.

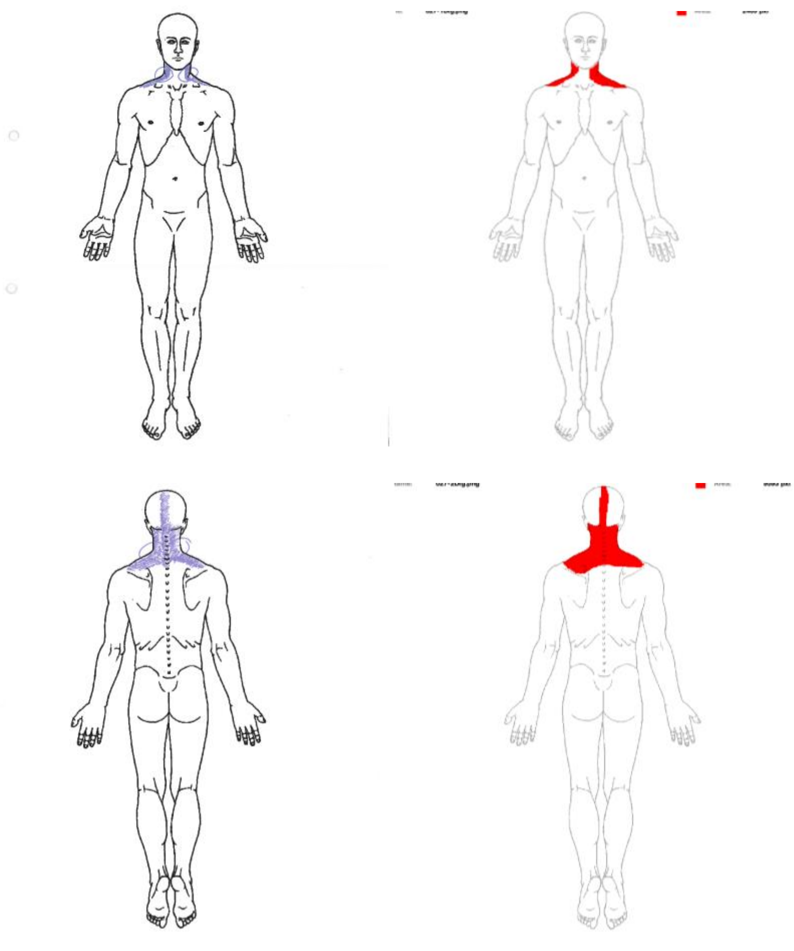

Figure 1 - Examples of identification of pain area from paper pain drawings.

(The body chart is printed on A4 paper with black squares (markers) and additional information according to the protocol. The patient is asked to color the painful areas with a blue or red pen, then the pain drawing is scanned, scaled and aligned using the black markers reference. The digital pain drawing is then analyzed as described in Figure 3.)

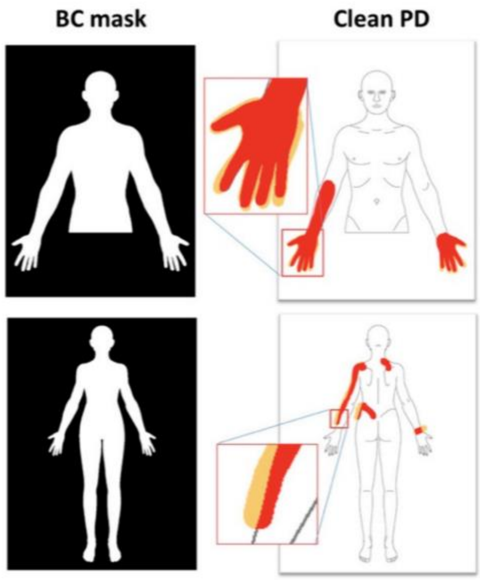

Figure 2 - Examples of pain drawing analysis.

(A mask is applied in order to remove the colored pixels outside the body chart area. The pixels of the clean pain draw (represented in red) are counted to obtain the pain area. The pixels outside the body chart (represented in orange) are discarded. From *Clinical Significance and Diagnostic Value of Pain Extent Extracted from Pain Drawings: A Scoping Review.* By Barbero M, Navarro-Santana MJ, Palacios-Ceña M, et al, 2020.)

2.3.2 Pain intensity

The Numeric Rating Scale (NRS) was used to assess the neck pain intensity (Cleland et al., 2008). The NRS is an 11-point scale, ranging from 0 (no pain) to 10 (worst pain imaginable). The cut-off values are as follows: minor (pain intensity <2), mild (2≤pain intensity<4), moderate (4≤pain intensity<6), and severe (pain intensity ≥6). It is widely used in the clinical setting, suitable for patients with neck pain, it is a valid and reliable instrument, and its use is recommended by the *Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials* (IMMPACT) (Blanpied et al., 2017; Cleland et al., 2008; Dworkin et al., 2005; Lemeunier et al., 2019; Young et al., 2019). It has a moderate to good test-retest reliability (ICC=0.76; 95% CI=0.51-0.87) and adequate responsiveness (AUC=0.85; 95% CI=0.78-0.93) for people with neck pain (Cleland et al., 2008; Koo & Li, 2016). If participants reported having experienced neck pain in the previous 4 weeks, they were asked to indicate their average neck pain in the previous 4 weeks. This applies to the participants in the 'neck pain group' and the 'neck pain and headache group'. If participants reported not having had neck pain at follow-up, the pain intensity was considered as 0.

2.3.3 Neck Pain Disability

The Neck Disability Index (NDI) questionnaire was used to assess the self-rated disability in participants with neck pain. The NDI questionnaire has 10 items: pain intensity, personal care, lifting, work, headaches, concentration, sleeping, driving, reading and recreation. Each item is rated on a six-point scale from 0 (no disability) to 5 (complete disability). The numeric responses for each item are summed for a total score ranging between 0 and 50. Higher scores correspond to higher disability levels, as follows: 0-4 points - no disability; 5-14 points - mild disability; 15-24 points - moderate disability; 25-34 points - severe disability; and 35-50 points - complete disability (Macdermid et al., 2009; Vernon, 2008; Young et al., 2019).

It is the most widely used and most strongly validated instrument to assess self-rated disability in patients with neck pain, with strong psychometric characteristics and high responsiveness (Cleland et al., 2008; Lemeunier et al., 2019; Macdermid et al., 2009; Vernon, 2008). It exhibited a fair to moderate test-retest reliability (ICC=0.50; 95% CI=0.26-0.67) and adequate responsiveness (AUC=0.83; 95% CI=0.75-0.90) for people with neck pain (Cleland et al., 2008; Koo & Li, 2016).

The German version of the NDI, used in the current study, has a comparable factor structure as the original version, with acceptable psychometric properties, acceptable reliability, strong construct validity and appropriate responsiveness (Cramer et al., 2014; Macdermid et al., 2009). As a measure of internal consistency Cronbach's α was 0.81, the split-half reliability of Spearman-Brown coefficient was 0.80 and the intra-class correlation was 0.81 (95% CI = 0.78-0.83). Significant associations were found for pain intensity ($r = 0.22$, $p < 0.01$), pain on movement ($r = 0.39$, $p < 0.01$), quality of life ($r = -0.30$ to -0.45, $p < 0.01$), and range of motion ($r = -0.34$, $p = 0.02$) (Cramer et al., 2014).

If participants reported having experienced neck pain in the previous 4 weeks, they were asked to complete the NDI questionnaire. This questionnaire was considered for the participants in the 'neck pain group' and the 'neck pain and headache group', but not for the participants in the 'headache group'. For analysis purposes, when the participants reported not having neck pain any longer at follow-up, and therefore the questionnaires have not been filled out, the score considered was 0. This approach was intended to minimize attrition and selection bias. By including participants who no longer experienced neck pain, the study avoided the risk of excluding a subset of individuals whose outcomes could provide valuable insights into the effects being measured. If these participants had been excluded, the data might have become incomplete or skewed, reflecting only those who continued to experience neck pain and excluding those who had shown improvement. This exclusion would lead to an overrepresentation of individuals with persistent pain, rather than a balanced view that includes also those who achieved recovery. Therefore, incorporating all participants, regardless of their current pain status, supports a more comprehensive and balanced analysis (Hernán & Hernández-Díaz, 2012).

2.3.4 Headache Disability

The Headache Impact Test (HIT-6) was used to assess the impact of headache among the participants who reported having headaches. HIT-6 is a six-question survey, that covers six aspects mostly impacted by headache: pain, role functioning (the ability to carry out usual activities), social functioning, energy or fatigue, cognition, and emotional distress (Martin et al., 2004). The total score derives from adding the responses to all items and can range from 36 (lowest score possible) to 78 (highest score possible). The assigned values to each possible response are as follows: 6 to "Never", 8 to "Rarely", 10 to "Sometimes", 11 to "Very often" and 13 to "Always". A score of 49 or less reflects little or no impact; scores between 50 and 55 reflect some headache impact; between 56 and 59 - substantial impact; and 60 or more reflect severe headache impact on the person's ability to function in everyday life (Martin et al., 2004).

This questionnaire is a valid, reliable and efficient screening tool, with good psychometric properties among headache sufferers (Kosinski et al., 2003; Rendas-Baum et al., 2014). It presented high indices of reliability (Cronbach's coefficient $\alpha = 0.87$), construct and face validity among patients seeking headache-specialty care (Kawata et al., 2004).

The German version used in the current study demonstrated good psychometric properties, equivalence of item functioning and adequate properties (Martin et al., 2004). It showed to be adequate in 7 out of 8 characteristics being tested: data completeness, range of responses used, order of item means, item scale $r \geq 0.40$, range of item-scale r's ≤ 0.30, internal consistency reliability $\alpha \geq 0.70$, and homogeneous item functioning.

If participants reported having experienced headaches in the previous 4 weeks, they were asked to complete the HIT-6 questionnaire. This questionnaire was considered for the participants in the 'neck pain and headache group' and in the 'headache group'. For analysis purposes, when the participants reported not having headaches any longer at follow-up, and therefore the questionnaires have not been filled out, we considered a score of 36 (lowest score possible) in order to minimize the attrition and selection bias (Hernán & Hernández-Díaz, 2012).

2.3.5 Headache Frequency

Clinical guidelines recommend headache frequency as a key outcome for assessing participants with headaches, given that previous studies have shown a decrease in frequency reflects clinical improvement, whereas high frequency is associated with greater disability (Becker et al., 2015; Bini et al., 2022; Demarquay et al., 2021; Gago-Veiga et al., 2021; Kaniecki, 2003; Kristoffersen et al., 2018; Niere & Jerak, 2004; Stewart et al., 2002). To evaluate this outcome, participants were asked if they experienced headaches in the previous 4 weeks (Yes/No). If they answered 'Yes', they were then asked on how many days of the month they have had headaches, while the participant had to write down the number of days (Aegerter et al., 2023).

2.3.6 Sociodemographic and Clinical Questionnaire

The sociodemographic and clinical questionnaire was developed by Aegerter et al. (2023) to characterize the participants regarding: age, gender, BMI (weight and height), civil status, qualifications, nationality, workload, income, smoking habits, physical activity levels, average and maximal neck pain intensity in the previous 4 weeks, and average and maximal headache intensity in the previous 4 weeks.

2.4 Secondary Analysis Process

The primary study had 120 participants at baseline, eight of which did not have neck pain nor headaches and were therefore excluded from this study. The remaining participants were divided into three groups: the participants who answered 'yes' to having had neck pain and 'no' to having had headaches in the previous four weeks were allocated to the 'neck pain group' (n=24); those who answered 'yes' to having had headaches and 'no' to having had neck pain in the previous four weeks were allocated to the 'headache group' (n=17); and those who answered 'yes' to both were allocated to the 'neck pain and headache group' (n=71). The outcomes of interest for the current study were selected based on the defined objectives for this secondary analysis, which includes the information collected from the sociodemographic and clinical questionnaire (described above); the pain extent from 6 defined areas (front neck, back neck, front left head, front right head, back left head, back right head) that was then summed to a new variable with the total PE of the head and neck area; the neck pain intensity; neck pain-related disability through the NDI score; headache-related disability through the HIT-6 total score; and the headache frequency.

2.5 Ethical Issues

The original study was submitted to the Ethics Committee of the Canton of Zurich, Switzerland, and approved on the 15th of October 2019 under the no. 2019-01678 (Aegerter et al., 2023). Additionally, it has been registered at *ClinicalTrials.gov* under the number NCT04169646. Secondary analysis studies were already included in the scope of original study. All the eligible participants received the information regarding the study's goals and had the possibility to clarify any questions before signing the Informed Consent. It was explained that participating was voluntary and that they could drop out at any moment, without having to justify it. Data confidentiality and participant anonymity was guaranteed by using a code for each assessment instrument. Its correspondence with the participant's name was known to the researchers only. The participants who voluntarily accepted to participate in the primary study signed the Informed Consent, which was then signed by the researcher, which is aligned with the *Good Clinical Research Practice* (Grady, 2018; Muthuswamy, 2013; World Health Organization, 2005).

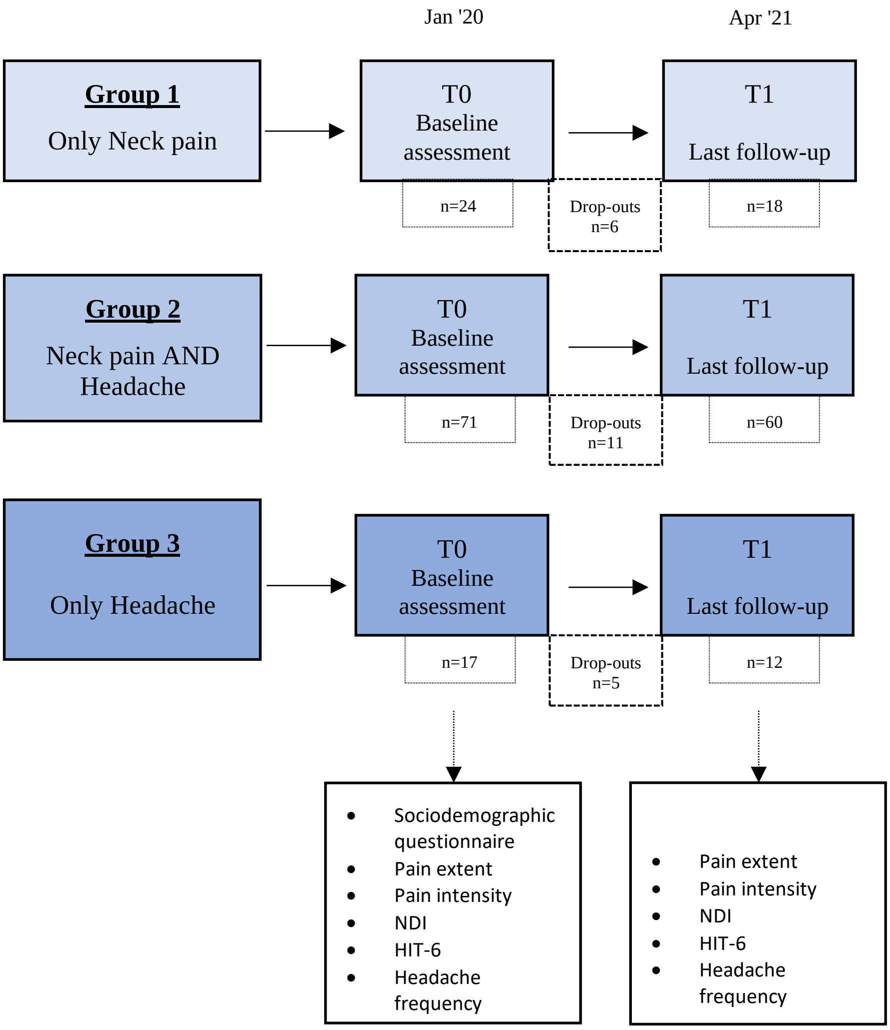

Figure 3- Flow-chart of the data collection.

2.6 Statistical analysis

Data was processed and analized with the *Statistical Package for the Social Sciences* (SPSS) software, version 29.0.2 (IBM Corporation, New York, USA) Macintosh. The sociodemographic and clinical characteristics were analyzed at baseline; and the outcome variables (PE, neck pain intensity, disability, headache frequency) were analyzed across two time points. Each variable was characterized through descriptive statistics. Nominal variables (sex, civil status, nationality, education, workload, income, smoking habits) were analyzed through frequency distribution (absolute and relative) and numerical variables (age, BMI, physical activity level, neck pain intensity, headache intensity, NDI score, HIT-

6 score, headache frequency) were analyzed through central tendency and dispersion measures (mean, median, standard deviation and interquartile range).

Regarding inferential statistics, data was tested for normal distribution using the *Shapiro-Wilk* test (Appendix 1) (Stehlik-Barry & Babinec, 2017). Normal distribution was not verified for most of the data, therefore non-parametric tests were used. To compare the three groups regarding their sociodemographic and clinical characteristics at baseline, the *Kruskal-Wallis* and the *Mann-Whitney U* tests was conducted for numerical variables and the *Chi-Square* test for nominal variables.

Within-groups analysis was performed, analyzing changes in PE, pain intensity, disability and headache frequency through central tendency and dispersion measures (median and interquartile range) for each group from baseline to last follow-up. To determine whether the observed changes were statistically significant, the *Wilcoxon Signed-Rank* test was performed (Stehlik-Barry & Babinec, 2017).

Associations between PE and neck pain intensity, disability, and headache frequency were analyzed for each group at both baseline and follow-up. Additionally, associations between changes in PE and changes in the other outcome variables from baseline to follow-up were examined. To assess these changes, new variables were created by calculating the difference between baseline and follow-up values for each variable of interest. To analyze these associations the *Spearman's rank-order correlation* was used (Stehlik-Barry & Babinec, 2017). The following classification was considered: negligible correlation for a correlation coefficient between 0.00-0.10; weak correlation between 0.10-0.39; moderate correlation between 0.40-0.69; strong correlation between 0.70-0.89; and very strong correlation between 0.90-1.00 (Schober & Schwarte, 2018).

The significance level was set at $p \leq 0.05$ (Confidence Interval of 95%), therefore the results were considered statistically significant when the probability value (p-value) of the test was equal or lower than 0.05 (Stehlik-Barry & Babinec, 2017).

3. Results

This chapter has two sections. The first section presents a descriptive analysis of the data related to the Sociodemographic (Table 1) and Clinical (Table 2) characteristics of each group: the 'neck pain group'; the 'neck pain and headache group' and the 'headache group'. The second section focuses on the inferential analysis of the outcome variables (PE, neck pain intensity, disability and headache frequency).

Considering the study’s objective and the inclusion and exclusion criteria, a total of 112 participants were included in this secondary analysis, which were divided into three groups based on pain location: 24 participants in the 'neck pain group', 71 participants in the 'neck pain and headache group' and 17 participants in the 'headache group'.

There were 22 dropouts between baseline and follow-up: seven due to job dismissal, six due to workload, two due to health problems, one because of an accident, one mentioned private reasons, and one gave no reasons. For participants who dropped out or had incomplete data, their last fully completed assessment was used for the analysis.

3.1 Sociodemographic and clinical characterization

The **'neck pain group'** (n= 24) had a mean (±standard-deviation) age of 44.63 (±9.93) years, with 54.2% (n=13) being female and 45.8% (n=11) male; and a mean BMI of 23.69 (±3.34). When it comes to workload 33.3% (n=8) work full time and 29.2% (n=7) work 80-89% (Table 1). The average[1] neck pain intensity on the NRS was 2.75 (±1.60) points and the maximal[1] neck pain intensity was 4.88 (±2.40) points. The participants had a 'mild' neck-related disability with a mean NDI score of 5.33 (±3.67) (Table 2).

The participants in the **'neck pain and headache group'** (n= 71) had a mean age of 43.35 (±9.70) years, with 80.3% (n=57) being female and 19.7% (n=14) male; and a mean BMI of 23.69 (±3.59). Regarding workload 38% (n=27) work full time and 21.1% (n=15) work 80-89%. The average[1] neck pain intensity was 3.07 (±1.85) points and the average[1] headache intensity was 4.48 (±2.08) points. The maximal[1] neck pain intensity was 5.24 (±2.35) points and the maximal[1] headache intensity was 7.01 (±2.09) points. This group had a 'mild' neck

[1]in the previous 4 weeks, at baseline

related disability as well, with a mean NDI score of 8.06 (±4.49); and 'some headache impact' with a mean HIT-6 score of 54.30 (±8.01).

Regarding the **'headache group'** (n=17), the participants presented a mean age of 45.06 (±9.83) years, with 64.7% (n=11) being female and 35.3% (n=6) male; and a mean BMI of 23.88 (±3.77). As to the workload, this group had the highest percentage (41.2%; n=7) of people working full time, followed by 29.4% (n=5) working 80-89%. The average[1] headache intensity was 4.53 (±2.42) points and the maximal[1] headache intensity was 7.06 (±2.46) points. Participants presented 'some headache impact' with a mean HIT-6 score of 51.00 (±7.13).

3.2 Analysis of the Clinical changes

Firstly, within-group courses from baseline to last follow-up will be described for each outcome (PE, pain intensity, disability, headache frequency) and for each group (1 - neck pain; 2 - neck pain and headache; 3 - headache). Subsequently, associations between PE and the other outcome variables (pain intensity, disability, and headache frequency) will be assessed for each group and for both time points. Lastly, associations between changes in PE and changes in the other outcome variables will be assessed within each group.

3.2.1 Within-groups Clinical Changes in Pain Extent, Neck Pain Intensity, Disability and Headache Frequency

Neck pain group

Over the course of the intervention, reductions in median values were found across all variables, except for neck pain intensity (Figure 4 and Table 3). The results indicate an improvement over time, with a significant (Z = -2.213; p=0.027) decrease in **PE** from a median of 20.23% (Q1-Q3: 9.11-26.22) to 10.60% (Q1-Q3: 0-18.87), similarly for the **NDI,** also reflecting a significant decrease (Z = -2.119; p=0.034) from a median of 4 (Q1-Q3: 2.25-6) to a median of 3 (Q1-Q3: 0-5). No significant changes (p>0.05) were found for neck pain intensity, since the median remained stable between baseline and end of treatment (median=2).

[1]in the previous 4 weeks, at baseline

Variable	Variable categories	Neck pain group	Neck pain and headache group	Headache group	p-value
Age	Years (mean±SD)	44.63 (±9.93)	43.35 (±9.70)	45.06 (±9.83)	0.818*
Sex % (n)	Female	54.2 (13)	80.3 (57)	64.7 (11)	**0.035****
	Male	45.8 (11)	19.7 (14)	35.3 (6)	
BMI	(mean±σ)	23.69 (±3.34)	23.69 (±3.59)	23.88 (±3.77)	0.992*
Civil status % (n)	Married	58.3 (14)	35.2 (25)	35.3 (6)	0.258**
	With partner	37.5 (9)	46.5 (33)	47.1 (8)	
	Single	4.2 (1)	18.3 (13)	17.6 (3)	
Nationality % (n)	Swiss	83.3 (20)	73.2 (52)	88.2 (15)	0.263**
	German	12.5 (3)	25.4 (18)	5.9 (1)	
	Other	4.2 (1)	1.4 (1)	5.9 (1)	
Education % (n)	Compulsory education	0	1.4 (1)	0	0.832**
	Upper secondary education	20.8 (5)	29.6 (21)	23.5 (4)	
	Tertiary level education	79.2 (19)	69 (49)	76.5 (13)	
Workload % (n)	<50%	4.2 (1)	1.4 (1)	0	0.917**
	50-59%	0	4.2 (3)	0	
	60-69%	12.5 (3)	7 (5)	11.8 (2)	
	70-79%	4.2 (1)	11.3 (8)	5.9 (1)	
	80-89%	29.2 (7)	21.1 (15)	29.4 (5)	
	90-99%	16.7 (4)	16.9 (12)	11.8 (2)	
	100%	33.3 (8)	38 (27)	41.2 (7)	
Income % (n)	2001-3000CHF	4.2 (1)	1.4 (1)	0	0.524**
	3001-4000CHF	4.2 (1)	1.4 (1)	5.9 (1)	
	4001-6000CHF	20.8 (5)	28.2 (20)	35.3 (6)	
	6001-8000CHF	25 (6)	35.2 (25)	17.6 (3)	
	8001-10.000CHF	33.3 (8)	19.7 (14)	11.8 (2)	
	10.001-15.000CHF	8.3 (2)	5.6 (4)	23.5 (4)	
	>15.000 CHF	0	1.4 (1)	0	
Smoking habits % (n)	No	66.7 (16)	67.6 (48)	58.8 (10)	0.957**
	Former smoker	20.8 (5)	22.5 (16)	29.4 (5)	
	Yes	12.5 (3)	9.9 (7)	11.8 (2)	
Physical activity level	MET/week (mean±SD)	3273.66 (±2916.10)	2290.63 (±206.19)	1685.43 (±1304.98)	0.301*

Table 1 - Sociodemographic characterization of each group, at baseline.

*(*p-value: Kruskal-Wallis test; **p-value: Chi-Square test; SD - standard deviation)*

Variable	Variable categories	Neck pain group	Neck pain and headache group	Headache group	p-value
Neck pain average[1]	NRS (mean±SD)	2.75 (±1.60)	3.07 (±1.85)	n/a	0.416*
Neck pain maximal[1]	NRS (mean±SD)	4.88 (±2.40)	5.24 (±2.35)	n/a	0.509*
Headache average[1]	NRS (mean±SD)	n/a	4.48 (±2.07)	4.53 (±2.43)	0.970*
Headache maximal[1]	NRS (mean±SD)	n/a	7.01 (±2.09)	7.06 (±2.46)	0.700*
Neck disability	NDI (mean±SD)	5.33 (±3.67)	8.06 (±4.49)	n/a	**0.004***
Headache disability	HIT-6 (mean±SD)	n/a	54.30 (±8.01)	51.00 (±7.13)	0.123*

Table 2 - Clinical characterization of each group, at baseline.
*(*p-value: Mann-Whitney U test; [1]in the previous 4 weeks, at baseline; n/a - non applicable; NRS - Numeric Rating Scale; NDI - Neck Disability Index; HIT-6 - Head Impact Test; SD - standard deviation)*

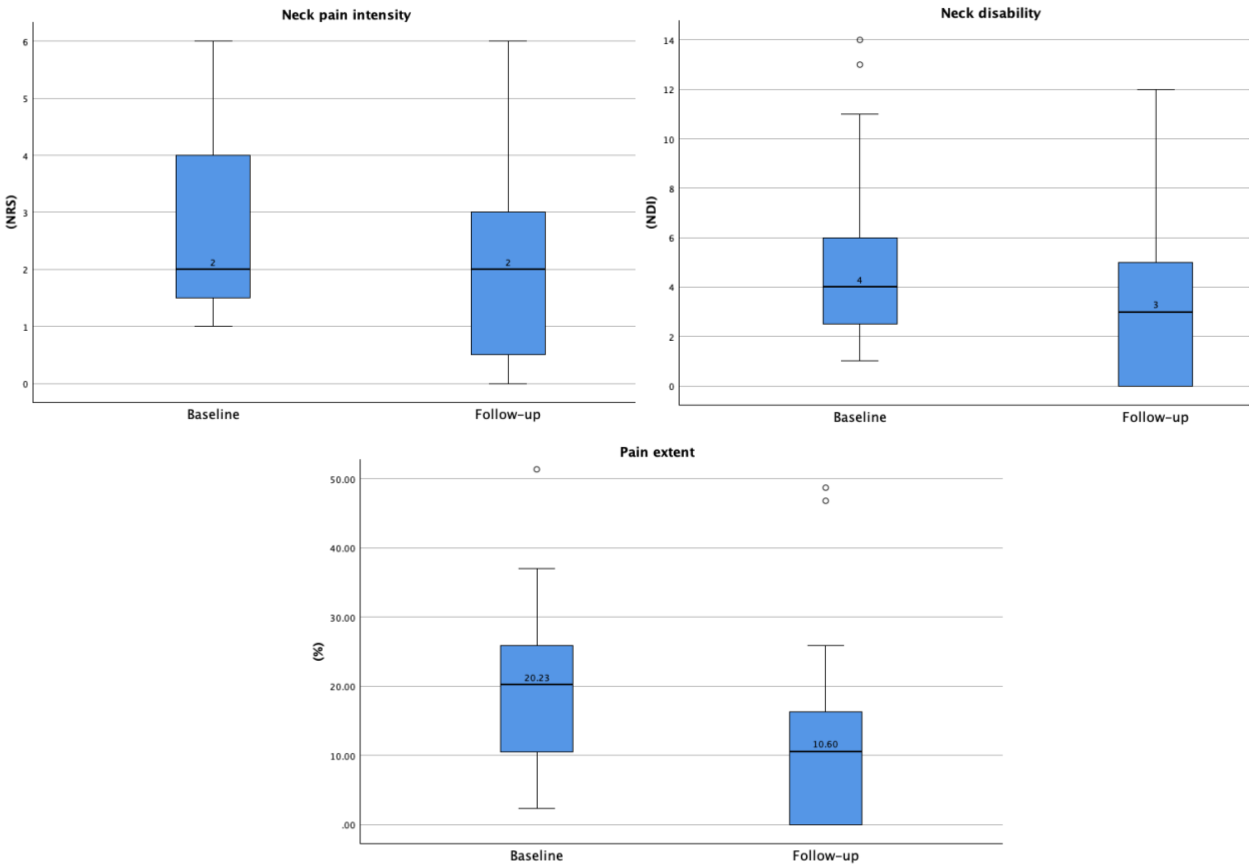

Figure 4 - Neck pain intensity, neck disability and pain extent distribution at baseline and follow-up in the 'neck pain group'.

Neck pain and headache group

Significant changes across all variables, except for neck pain intensity could be found. (Figure 5 and Table 3). There was a significant decrease in **PE,** with the median value decreasing from 23.62% (Q1-Q3: 11.51-34.44) to 15.86% (Q1-Q3: 2.47-34.04). Similarly, the **NDI** score showed a significant decrease from a median of 8 (Q1-Q3: 5-11) to a median of 7 (Q1-Q3: 0-11) ($Z = -2.211$; $p=0.027$). For the **HIT-6** scores, the median decreased significantly from 54 (Q1-Q3: 47.75-59.25) to 50 (Q1-Q3: 37.5-55) ($Z = -4.333$; $p<0.001$). Additionally, **headache frequency** decreased significantly ($Z = -2.306$; $p=0.021$) although the median remained consistent at 3 over time. No significant changes were found for neck pain intensity ($p>0.05$), as the median remained stable over time (median=2).

Headache group

All variables, except PE demonstrated significant changes between baseline and last follow-up. (Figure 6 and Table 3), which suggest an improvement over time. The **HIT-6** scores decreased significantly from a median of 53 (Q1-Q3: 46–55.5) to 36 (Q1-Q3: 36–49) ($Z = -2.745$, $p=0.006$). Additionally, **headache frequency** showed a significant reduction ($Z = -2.114$, $p=0.035$), with the median decreasing from 2 (Q1-Q3: 1.25–5) to 0 (Q1-Q3: 0–4.5). In contrast, although there was a reduction in PE from a median of 11.03% (Q1-Q3: 3.58–19.01) to 6.61% (Q1-Q3: 0–35.88), these changes were not statistically significant ($p>0.05$).

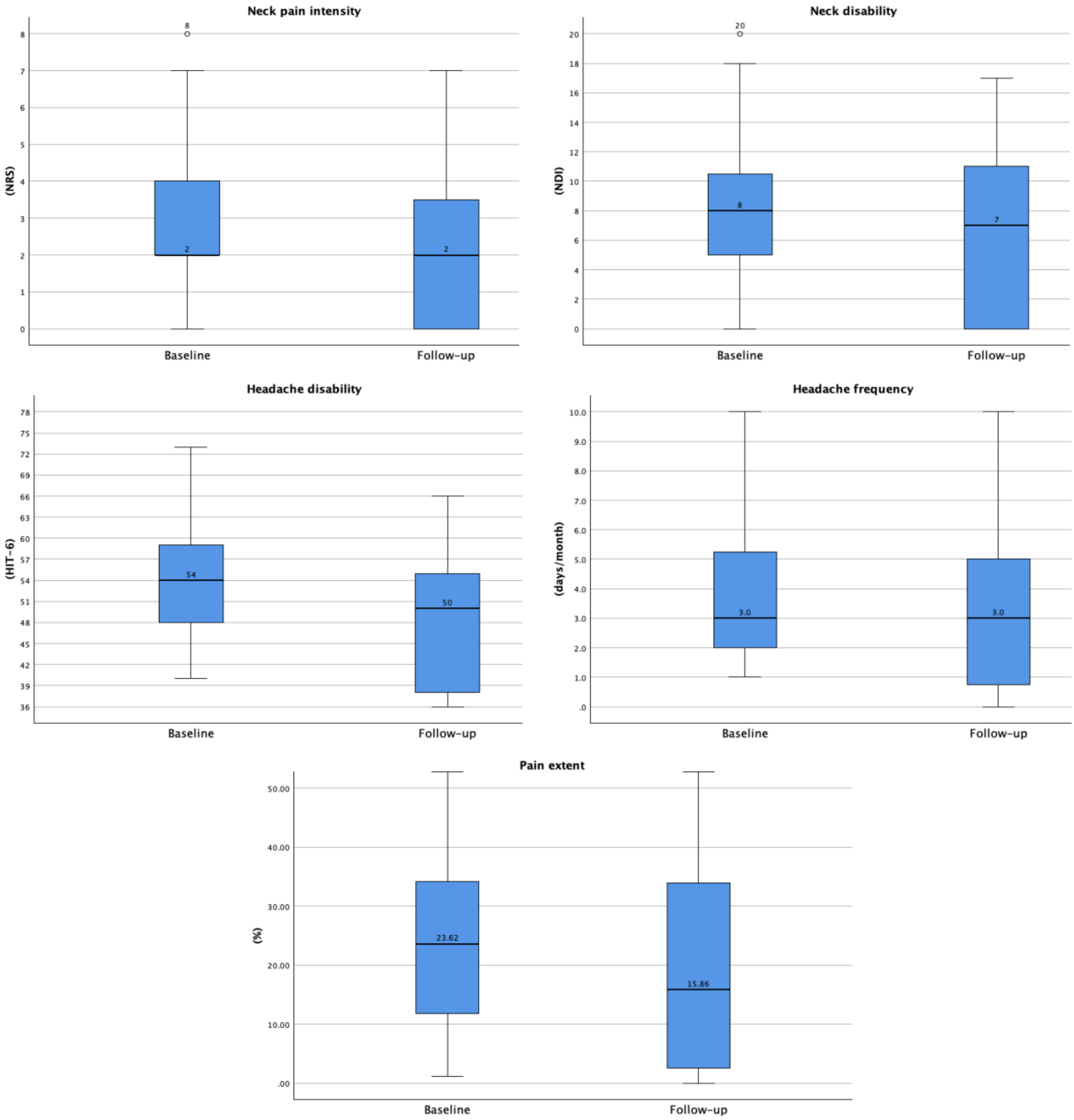

Figure 5 - Neck pain intensity, neck disability, headache disability, headache frequency and pain extent distribution at baseline and follow-up in the 'neck pain and headache group'.

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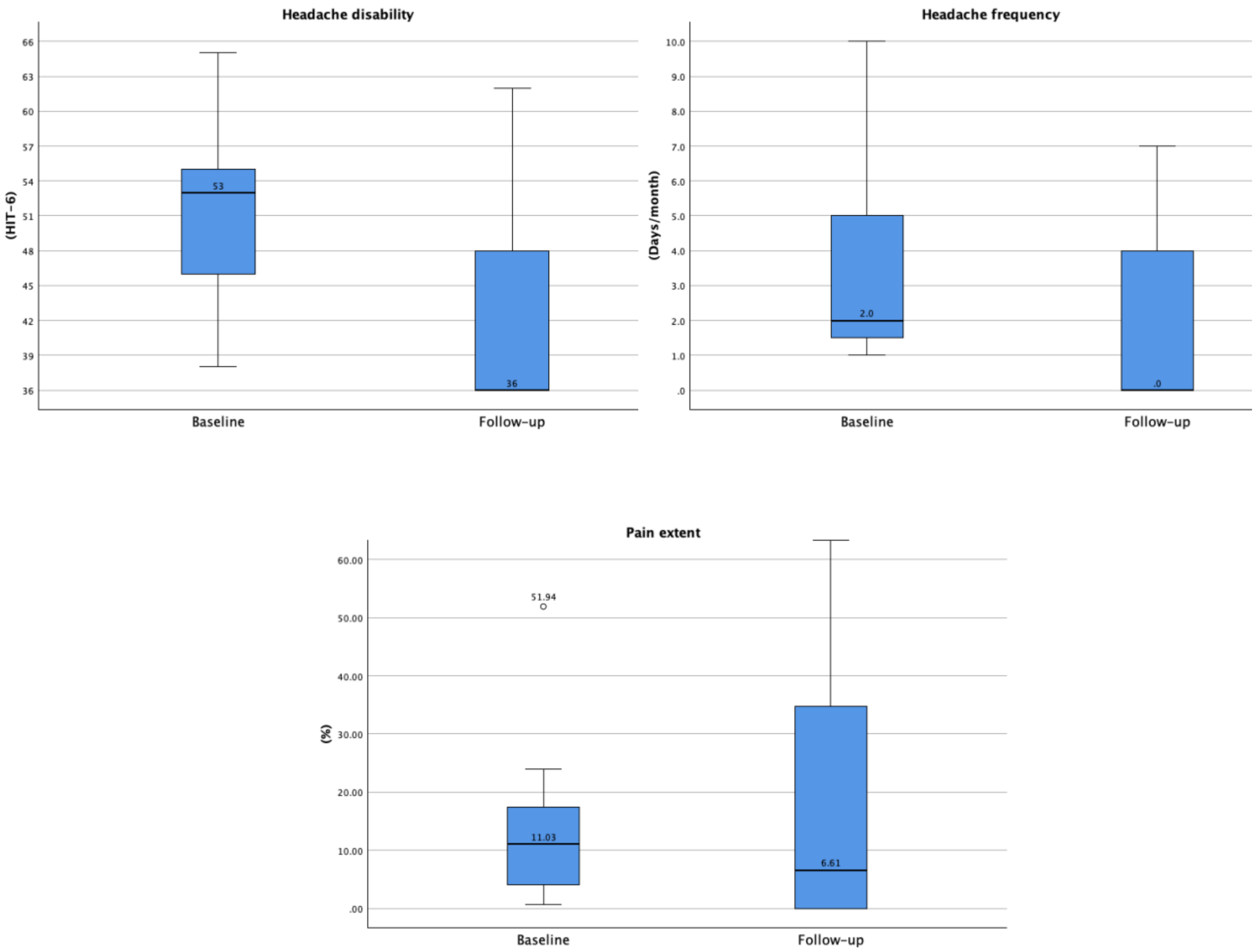

Figure 6 - Headache disability, headache frequency and pain extent distribution at baseline and follow-up in the 'headache group'.

Variable	Group	Baseline		Follow-up		Z	p-value
		median	Q1-Q3	median	Q1-Q3		
PE (%)	Neck	20.23	9.11 - 26.22	10.60	0 - 18.87	-2.213	**0.027**
	Neck & headache	23.62	11.51 - 34.44	15.86	2.47 - 34.04	-2.480	**0.013**
	Headache	11.03	3.58 - 19.01	6.61	0 - 35.88	-5.33	0.594
Neck pain intensity (NRS)	Neck	2	1.25 - 4	2	0 - 3	-0.934	0.350
	Neck & headache	2	2 - 4	2	0 - 4	-1.274	0.203
	Headache	n/a	n/a	n/a	n/a	n/a	n/a
NDI (score)	Neck	4	2.25 - 6	3	0 - 5	-2.119	**0.034**
	Neck & headache	8	5 - 11	7	0 - 11	-2.211	**0.027**
	Headache	n/a	n/a	n/a	n/a	n/a	n/a
HIT-6 (score)	Neck	n/a	n/a	n/a	n/a	n/a	n/a
	Neck& headache	54	47.75 - 59.25	50	37.5 - 55	-4.333	**<0.001**
	Headache	53	46 - 55.5	36	36 - 49	-2.745	**0.006**
Headache frequency (days per month)	Neck	n/a	n/a	n/a	n/a	n/a	n/a
	Neck & headache	3	2 - 5.5	3	0.5 - 5	-2.306	**0.021**
	Headache	2	1.25 - 5	0	0 - 4.5	-2.114	**0.035**

Table 3 - Within-group clinical changes in pain extent, neck pain intensity, neck pain-related disability, headache-related disability, and headache frequency, at beaseline and follow-up. (Z and p-value: Wilcoxon Signed-Rank test; n/a - non applicable; NRS - Numeric Rating Scale; NDI - Neck Disability Index; HIT-6 - Headache Impact Test)

3.2.2. Associations between Pain Extent and Neck Pain intensity, Disability and Headache frequency

3.2.2.1 Baseline and follow-up

A *Spearman's rank-order correlation* was conducted to assess the relationship between PE and neck pain intensity, disability, and headache frequency, at baseline and follow-up (Table 4) (Schober & Schwarte, 2018).

In the **'neck pain group'**, no significant associations ($p>0.05$) were found between PE and neck pain intensity, nor between PE and NDI scores, at either baseline or follow-up. This finding suggests that among participants with isolated neck pain, there seems to be no meaningful relationship between PE and pain intensity, nor PE and disability.

In contrast, in the **'neck pain and headache group'**, significant correlations were observed, indicating an association between PE and clinical outcomes. At follow-up, a moderate positive correlation ($r_s=0.438$; $p<0.001$) was found between PE and **neck pain intensity**; and a weak positive correlation ($r_s=0.377$; $p=0.002$) between PE and **HIT-6** scores. These findings suggest that larger PE seems to be associated with higher neck pain intensity and greater headache-related disability, at follow-up. A weak positive correlation ($r_s=0.247$; $p=0.038$) was observed between PE and **NDI** at baseline; and a moderate positive correlation ($r_s=0.448$; $p<0.001$) at follow-up. A significant association was also observed between PE and **headache frequency**, with a weak positive correlation at baseline ($r_s=0.376$; $p=0.001$) and a moderate positive correlation at follow-up ($r_s=0.457$; $p<0.001$). In the **'headache group'**, significant correlations were observed at follow-up. Specifically, a strong positive correlation was found between PE and **headache frequency** ($r_s=0.746$, $p<0.001$), along with a moderate positive correlation ($r_s=0.692$, $p=0.002$) between PE and **HIT-6** scores.

		Neck pain group			Neck pain and headache group			Headache group		
		n	r_s	p-value	n	r_s	p-value	n	r_s	p-value
PE *and* **Neck pain intensity**	T0	23	0.393	0.064	71	0.187	0.119	n/a	n/a	n/a
	T1	21	0.224	0.329	63	0.438	**<0.001**	n/a	n/a	n/a
PE *and* **NDI**	T0	23	0.326	0.129	71	0.247	**0.038**	n/a	n/a	n/a
	T1	22	0.251	0.259	63	0.448	**<0.001**	n/a	n/a	n/a
PE *and* **HIT-6**	T0	n/a	n/a	n/a	70	0.194	0.108	17	0.294	0.251
	T1	n/a	n/a	n/a	63	0.377	**0.002**	17	0.692	**0.002**
PE *and* **Headache frequency**	T0	n/a	n/a	n/a	71	0.376	**0.001**	17	0.377	0.136
	T1	n/a	n/a	n/a	63	0.457	**<0.001**	17	0.746	**<0.001**

Table 4 - Pain extent correlation with neck pain intensity, neck pain-related disability, headache-related disability, and headache frequency, at baseline and follow-up.
(r_s: Spearman's rank-order correlation coefficient; n/a - non applicable; T0 - baseline; T1 - follow-up; NDI - Neck Disability Index; HIT-6 - Headache Impact Test)

3.2.2.2. Changes over time

To further understand the relationship between changes in PE over time and changes in neck pain intensity, disability and headache frequency, a *Spearman's rank-order correlation* analysis was conducted on the differences between baseline and follow-up values (Table 5) (Schober & Schwarte, 2018). In the **'neck pain group'**, no significant associations ($p>0.05$) were found. Considering the **'neck pain and headache group'** a moderate positive correlation ($r_s=0.449$, $p<0.001$) was observed between changes in PE and changes in **neck pain intensity**, along with a weak positive correlation ($r_s=0.295$, $p=0.019$) with changes in **NDI** scores. No significant associations were found between changes in PE and changes in HIT-6 scores, nor in headache frequency. In the **'headache group'**, no significant associations ($p>0.05$) were observed.

	Neck pain group			**Neck pain and headache group**			**Headache group**		
	n	r_s	p-value	n	r_s	p-value	n	r_s	p-value
PE *and* Neck pain intensity	22	0.150	0.515	63	0.449	**<0.001**	n/a	n/a	n/a
PE *and* NDI	22	0.203	0.365	63	0.295	**0.019**	n/a	n/a	n/a
PE *and* HIT-6	n/a	n/a	n/a	62	0.209	0.103	17	0.262	0.309
PE *and* Headache frequency	n/a	n/a	n/a	63	0.167	0.191	17	-0.100	0.702

Table 5 - Correlations between changes in pain extent and changes in neck pain intensity, neck pain-related disability, headache-related disability, and headache frequency, from baseline to follow-up.
(r_s: Spearman's rank-order correlation coefficient; n/a - non applicable; NDI - Neck Disability Index; HIT-6 - Headache Impact Test)

4. Discussion

The primary objective of this study was to investigate the relationship between changes in PE and changes in commonly used clinical outcomes, such as pain intensity, disability and headache frequency; in office workers with neck pain and/or headache, that underwent a neck strength and endurance exercise program combined with health-promotion information and workplace ergonomics (NEXpro). As such, a secondary analysis was conducted, where participants were divided into three groups according to their pain location. The relationship between PE and neck pain intensity, disability and headache frequency, as well as their changes, were investigated over time.

Regarding the Sociodemographic and Clinical characteristics of the population in this study, the groups were homogeneous in all the variables except for sex and neck-related disability. There was heterogeneity between the groups regarding their sex (p=0.035), because there is one group with 80.3% females, whereas the other two have 54.2% and 64.7%. Nevertheless, there was a higher percentage of females in all groups. This is supported by the literature, as there is a higher prevalence of neck pain, headaches, and the combination of both, in females (Im et al., 2023; Irgens et al., 2022; Kazeminasab et al., 2022; Liang et al., 2022; Matharu et al., 2024). The highest burdens of neck pain are reported to be between 45 and 54 years, and the mean age among headache sufferers ranges between 38.8 and 43.1 years, which is in line with our findings (Irgens et al., 2022; Kazeminasab et al., 2022; Liang et al., 2022; Matharu et al., 2024).

Based on existing literature it is known that long duration of daily computer use is a risk factor for neck pain, possibly due to sustained postures that cause prolonged static loads, lack of physical activity, and perceived stress (Ernst et al., 2023; Kazeminasab et al., 2022; Magnavita, 2022; Rodrigues et al., 2017). This is reflected in our results, since most participants work between 34h/week (80% workload) and 42h/week (100% workload) (Kazeminasab et al., 2022).

Participants in this study reported levels of neck pain intensity (ranging from mild to moderate) that are consistent with previous studies, at baseline (first assessment before starting intervention). For comparison, a study on the clinical course of neck pain involving

1124 participants reported a mean neck pain intensity of 4.0 (±2.2) points (mild to moderate) at baseline (Irgens et al., 2022). Similarly, a longitudinal study with 50 participants found a mean neck pain intensity of 5.5 (±1.8) points (moderate) at baseline (Walton et al., 2014). Vasseljen et al. (2013) studied the natural course of neck pain and reported a mean neck pain intensity of 3.6 (±1.7) (mild) and a maximal pain in the previous four weeks of 5.4 (±2.2) (moderate).

The headache intensity reported by the participants (moderate to severe) was also concordant with the literature. For reference, since most participants' headache was classified as migraine or tension-type, the mean migraine intensity typically ranges between 5.7 and 7.0 points (moderate to severe) and there is a reported mean tension-type headache intensity of 6.73 (±1.03) points (severe) (Al-Khazali et al., 2024; Liang et al., 2022; Singh et al., 2023).

As to disability, the 'neck pain and headache group' had a significantly higher neck pain-related disability with an 8.06 (±4.49) NDI score, whereas the 'neck pain group' had a 5.33 (±3.67) NDI score; even though both fall under the 'mild disability' classification. There is evidence that the NDI score in migraine is influenced by neck pain frequency and intensity (Liang et al., 2022). These findings corroborate existing evidence that those who report neck pain during their headache experience, particularly those with migraine and tension-type headache, have higher levels of disability than those with headache only (Ashina et al., 2015; Liang et al., 2022; Matharu et al., 2024).

Additionally, about a third of people with migraine who also experience neck pain, report neck pain as the most bothersome symptom (Matharu et al., 2024). However, this could as much be due to pain and sensitivity associated with migraine, as due to nociception and physical limitations of the cervical spine (Ashina et al., 2015; Delen & İlter, 2023; Ernst et al., 2023; Getsoian et al., 2020; Irgens et al., 2022; Jull, 2023; Liang et al., 2022; Matharu et al., 2024; Satpute et al., 2023; Uthaikhup et al., 2020).

The headache-related disability was similar in both groups and corresponds to 'some headache impact' for both. Similar scores have been previously reported: a mean HIT-6 score of 56.73 (±7.49) for migraine; and of 54.00 (±8.60) for tension-type headache (Bera et al., 2014). Contrary to the neck pain-related disability with the presence of headache, the headache-related disability was not significantly influenced by the presence of neck pain in this study. This corroborates, once again, that the presence of neck pain in headache conditions seems to lead to an increased burden (Matharu et al., 2024).

Considering the within-groups changes, all variables improved significantly, except for PE in the 'headache group', and neck pain intensity for all groups. The 'headache group' not having improved in PE corroborates the findings of Barbero et al. (2020) that PE might not be associated with clinical outcomes in non-musculoskeletal conditions, such as headache (conditions associated to a deficient regulation of excitatory-inhibitory balance and activation of the trigemino-vascular system).

It is intriguing that no significant changes were found for neck pain intensity, that being the most used outcome measure in clinical practice. It might be related to the chosen intervention or due to the low intensity of pain and long time-period between the measurements (Irgens et al., 2022; Vasseljen et al., 2013). Neck pain intensity ranged from 1.25 (Q1) to 4 (Q3) points at baseline (minor to mild) and at follow-up, 16 months later, it ranged from 0 (Q1) to 3 (Q3) points (none and minor to mild). These results are supported by previous findings that minor neck pain intensities are rather recalcitrant to further improvements so significant changes were not to be expected (Irgens et al., 2022; Vasseljen et al., 2013).

Pain intensity is commonly used as an outcome measure, especially in clinical settings. However, pain is a multidimensional experience, that requires a comprehensive assessment (Barbero et al., 2020; Palacios-Ceña et al., 2017; Uthaikhup et al., 2024). Clinical improvement should be considered as the integrated response of patients' perception and interpretation, which needs to include pain intensity, location and extent; along with functional state and quality of life (Uthaikhup et al., 2024). As such, a multidimensional pain assessment should be conducted to encompass various aspects of a patient's pain experience, which may include the addition of PDs (Uthaikhup et al., 2024).

When it comes to the association between PE and other outcome variables, there were heterogeneous results across all three groups. In the 'neck pain group', there were no associations found between PE and neck pain intensity, nor between PE and disability. Previous studies showed that PE was positively associated with pain intensity and disability, in mechanical, work-related and chronic neck pain (Barbero et al., 2020; Falla et al., 2016; Uthaikhup et al., 2024). Accordingly, associations in this group were expected. It might be possible that these findings were not reflected in our study due to the relatively small sample size or due to the minor neck pain intensity (Bonita et al., 2006; Irgens et al., 2022; Lambert, 2011; Stuckless & Parfrey, 2021). People with neck pain have oftentimes associated radiating pain to the shoulder, arm and hand regions (Ludvigsson et al., 2020). As such, including those areas in the data collection and analysis could have led to better associations between PE and neck pain intensity and disability.

In the 'neck pain and headache group', PE was associated with all outcomes, although not at both time points. At baseline, no association was found between PE and neck pain intensity, which could be due to the low pain intensity compared to the large PE. At follow-up, however, PE was associated with pain intensity. It is possible that the decrease in PE made it more concordant with the low pain intensity. Although there are studies confirming that a larger PE is associated with higher neck pain intensity (Barbero et al., 2020; Falla et al., 2016; Ris et al., 2019), Uthaikhup et al. (2024) reported a similar finding as this study. The authors found associations for some of the time points only, with a decreasing association over time, and some of the patients had a discordant response over time. The association between PE and neck pain intensity seems to change depending on the time point when data was collected, which suggests that PE may not reflect the intensity of pain in this group.

Our findings regarding neck pain-related disability are in line with previous studies, a larger PE seems to be associated with greater disability, at baseline and at follow-up (Barbero et al., 2020; Falla et al., 2016; Ris et al., 2019; Uthaikhup et al., 2024).

Considering the headache-related disability, the results were consistent for the 'neck pain and headache group' and the 'headache group', although the correlation coefficient was stronger in the 'headache group'. The involvement of the neck area in the PE value might make it less concordant with the HIT-6 score, than when only the head area is involved. Associations were found at follow-up only, with a larger PE being associated with a greater disability. Since associations were found only at follow-up, PDs might not reflect the HIT-6 scores in a consistent manner.

A previous study found no association between PE and clinical features, such as headache frequency (Fernández-De-Las-Peñas et al., 2018). Our results contradict their findings, as a larger PE was associated with a higher headache frequency, at both time points. The differences are possibly related to the population being studied, since the authors reported these results for migraine patients (Fernández-De-Las-Peñas et al., 2018).

In the 'headache group', no associations were found at baseline; but at follow-up, a larger PE was associated with greater disability and with higher headache frequency. A possibility as to why there were no associations found at baseline, is that because the head does not have a big area, the PE (area of pain) was relatively low, while the disability and headache frequency were high. At follow-up, the disability and headache frequency were significantly lower, becoming more concordant with the low PE. Besides, some participants did not have headaches at follow-up, which means there were several participants scoring the minimal values at all the variables (PE, HIT-6, headache frequency) and therefore there was concordance between them. Considering the discordant results at each time point, PDs might not reflect properly the disability levels in this group (Kawata et al., 2004; Uthaikhup et al., 2024).

Surprisingly, the associations found between the variables at baseline and follow-up are not reflected in the associations between the variables' changes over time. Probably, the variables that were associated at both time points might also show associations in their changes over time. However, the results proved differently. Significant associations were only found in the 'neck pain and headache group', between PE and neck pain intensity, and between PE and neck pain-related disability. PDs might not have the ability to capture the clinical changes that other instruments can (Barbero et al., 2020; Uthaikhup et al., 2020). PDs did not show the improvement in headache-related outcomes such as disability and headache frequency.

Nevertheless, our results indicate that PDs reflect the clinical improvement in neck pain intensity and neck pain-related disability in participants with neck pain and headaches, when present simultaneously. These associations were not observed for participants who have isolated neck pain, which could be either due to the smaller sample size for that group, or because of the relatively smaller area of pain, since only the neck area was involved, contrary to the 'neck pain and headache group' that had an overall larger area of pain (Bonita et al., 2006; Lambert, 2011; Ross & Zaidi, 2019; Stuckless & Parfrey, 2021). Since previous studies have considered an area as painful only when the PE was above 10%, and considering our results, it is possible that PDs can only capture clinical changes starting from a certain area value, not being suitable for conditions that have a relatively small area of pain (Falla et al., 2016; Pitance et al., 2021).

Some of our findings contradict previously published studies, either because the population in this study leads to different results, or because of the limitations of this study. These limitations should be taken into consideration when interpreting the results.

The main limitation is this being a secondary analysis, allowing for the analysis of the available data that was not planned and collected according to this study's objective (Baldwin et al., 2022; Trinh, 2018; Wickham, 2019; Windle, 2010). It also entails limitations such as selection bias and response bias (Lambert, 2011; Ross & Zaidi, 2019; Stuckless & Parfrey, 2021; Trinh, 2018; Wickham, 2019). The sample size was different between groups, with the 'neck pain and headache group' having better chances of achieving a significant result, due to the significantly larger sample size. The results for the other two groups might be less precise with higher chances of committing a type II error of not finding significant associations, even if they are there (Bonita et al., 2006; Lambert, 2011; Ross & Zaidi, 2019; Stuckless & Parfrey, 2021).

No differentiations between headache types and/or states, such as primary or secondary headaches, frequent or chronic states, were considered in the current study, even though different headache types are likely of having been included in the current study (Barbero et al., 2020; Fuensalida-Novo et al., 2020; Uthaikhup et al., 2020). The findings might likely be different for different headache type and depending on the condition duration (episodic vs chronic) (Barbero et al., 2020; Fuensalida-Novo et al., 2020; Uthaikhup et al., 2020). Headache intensity may have been a relevant outcome for this study, but this data was collected at baseline only, as headache was not the focus of the original study (Becker et al., 2015; Bini et al., 2022; Demarquay et al., 2021; Kaniecki, 2003; Niere & Jerak, 2004; Stewart et al., 2002).

Participants were divided into groups according to their pain location at baseline, however, it is possible that participants in the 'neck pain group' had associated episodic headache or participants in the 'headache group' has associated neck pain that did not fall under the provided time-frame. It is also possible that these complaints developed over the course of the study, which would impact the PE, but not the other outcomes, making it less likely to find associations in these groups.

The original study is a stepped-wedge cluster randomized controlled trial, with three cohorts, which means that all participants received the intervention, but at different time points (Aegerter et al., 2023). In this study, we refrained from further dividing groups into cohorts, according to the time point participants had been randomized to the intervention phase, as groups would have become even more unequal and smaller. Since our objective was not primarily in assessing the efficacy of the intervention, but to assess associations between changes in PE and changes in other outcome variables, further division of groups was not regarded relevant.

Nevertheless, the follow-up (post-intervention) measurements corresponded to different time points for different participants. Even though participants were encouraged to continue performing the exercises autonomously after being submitted to the intervention, the final follow-up, as has been used in the current study, was for some the immediate post-intervention follow-up, while for others the supervised intervention phase was 4 or 12 months prior. For the first cohort randomized to the intervention, the last follow-up was after 12-month instead of an 8-month follow-up, as originally been planned, because the study was extended for 4 months due to COVID lockdown in spring 2020, with a total study duration of 16 months instead of 12 months (Aegerter et al., 2023). This considered and as suggested by Uthaikhup et al. (2024), the associations found at different follow-up points might differ, which should be taken into account when interpreting our results.

Lastly, to minimize attrition bias, we imputed the minimal neck pain-related or headache-related disability score for participants who reported not having experienced neck pain or headache, at follow-up (Bonita et al., 2006; Lambert, 2011; Ross & Zaidi, 2019; Stuckless & Parfrey, 2021). Questionnaires were meant to be filled out only by participants who reported pain in that region, headache or neck pain, and not by those participants that reported not having pain any longer (Macdermid et al., 2009; Martin et al., 2004). Real values may differ from imputed ones.

To better understand the utility of PDs in neck pain and in headache and to get accurate results, future research should be conducted with an equal number of participants for each group or a more homogenous single group, to minimize selection bias and allow for results that are representative of the population with these conditions (Bonita et al., 2006; Hajian-Tilaki, 2014; Ross & Zaidi, 2019; Stuckless & Parfrey, 2021). It would be important to separate the participants according to pain duration (acute, subacute, chronic), as well as to their neck pain origin and headache type, since previous studies have reported different results according to these classifications (Barbero et al., 2020; Falla et al., 2016; Fernández-De-Las-Peñas et al., 2018; Fuensalida-Novo et al., 2020; Palacios-Ceña et al., 2017; Ris et al., 2019; Uthaikhup et al., 2020). Data should be collected at several time points, with equal recall periods for all outcomes, because the associations between PE and clinical outcomes might change according to when the measurements were taken (Uthaikhup et al., 2024). The influence of the area of pain should be investigated further, as the association between PE and clinical outcomes in small areas, such as only neck or only head remains unclear.

Despite its limitations, this study may have important contributions for the assessment of headache and neck pain. PDs may be completed by patients in physiotherapy settings and compared between start and end of interventions even though, even more so because simple calculations of PE are being developed (Barbero et al., 2024).

5. Conclusion

This study contributes to the understanding of the associations between PE and other outcome variables, as well as the associations between their changes, in office workers with neck pain, headache, or both. The findings suggest that in office workers with isolated **neck pain**, PE does not appear to be associated with pain intensity, nor disability. The associations found for office workers with isolated **headache** were not consistent over time, indicating that PE may not be reliably associated with disability or headache frequency in these population. Moreover, changes in PE were not associated with changes in other outcomes variables in either group.

In office workers experiencing both **neck pain and headache** simultaneously, a larger PE appears to be associated with greater neck pain-related disability and headache frequency. However, the associations observed for neck pain intensity and headache-related disability were inconsistent over time. Notably, this was the only group where changes in PE were associated with changes in other outcomes. Specifically, a decrease in PE seems to be associated with a decrease in neck pain intensity and with a decrease in neck pain-related disability.

Some of our findings contradict previously published studies, potentially due to differences in the studied population or the limitations of this research. Therefore, further studies are necessary to address these limitations. Further research should also consider separating participants by pain duration, pain origin (for neck pain), and headache type, while collecting data at multiple time points. In conclusion, the utility of PDs seems to be limited in conditions characterized by smaller pain areas, such as isolated neck pain or isolated headache. Nevertheless, when assessing office workers experiencing both neck pain and headache simultaneously, PDs could serve as a valuable complement to other clinical and patient-reported outcomes, offering unique insights into the spatial distribution and extent of pain. Incorporating PDs alongside other measures could enhance the depth and precision of the assessment, ultimately improving the ability to tailor interventions to the specific needs of each individual. It is essential to conduct a multidimensional assessment that captures the various facets of an individual's pain experience. This comprehensive strategy enables a more holistic understanding of pain by integrating multiple outcome measures.

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Appendix

Appendix 1

Tests of normality for age

Tests of Normality

	GROUP	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
age	neck pain	.108	24	.200*	.963	24	.502
	both	.100	71	.077	.972	71	.106
	headache	.149	17	.200*	.931	17	.223

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Tests of normality for sex

Tests of Normality

	GROUP	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
sex	neck pain	.358	24	<.001	.637	24	<.001
	both	.491	71	<.001	.487	71	<.001
	headache	.410	17	<.001	.611	17	<.001

a. Lilliefors Significance Correction

Tests of normality for BMI

Tests of Normality

	GROUP	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
BMI	neck pain	.114	24	.200*	.972	24	.726
	both	.065	71	.200*	.965	71	.043
	headache	.179	17	.148	.810	17	.003

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Tests of normality for civil status

Tests of Normality

	GROUP	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
civil status	neck pain	.374	24	<.001	.650	24	<.001
	both	.302	71	<.001	.734	71	<.001
	headache	.300	17	<.001	.739	17	<.001

a. Lilliefors Significance Correction

Tests of normality for nationality

Tests of Normality

	GROUP	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
nationality	neck pain	.497	24	<.001	.460	24	<.001
	both	.456	71	<.001	.557	71	<.001
	headache	.513	17	<.001	.391	17	<.001

a. Lilliefors Significance Correction

Tests of normality for education level

Tests of Normality

	GROUP	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
education	neck pain	.484	24	<.001	.503	24	<.001
	both	.431	71	<.001	.614	71	<.001
	headache	.469	17	<.001	.533	17	<.001

a. Lilliefors Significance Correction

Tests of normality for income

Tests of Normality

	GROUP	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
income	neck pain	.204	23	.014	.916	23	.055
	both	.212	66	<.001	.908	66	<.001
	headache	.233	16	.020	.864	16	.022

a. Lilliefors Significance Correction

Tests of normality for workload

Tests of Normality

	GROUP	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
work	neck pain	.201	24	.013	.860	24	.003
	both	.211	71	<.001	.854	71	<.001
	headache	.243	17	.009	.836	17	.007

a. Lilliefors Significance Correction

Tests of normality for smoking habits

Tests of Normality

	GROUP	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
smoking	neck pain	.409	24	<.001	.640	24	<.001
	both	.419	71	<.001	.623	71	<.001
	headache	.367	17	<.001	.684	17	<.001

a. Lilliefors Significance Correction

Tests of normality for physical activity level

Tests of Normality

	GROUP	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
MET_week	neck pain	.219	19	.017	.889	19	.031
	both	.213	53	<.001	.820	53	<.001
	headache	.314	11	.003	.792	11	.007

a. Lilliefors Significance Correction

Tests of normality for average neck pain intensity at baseline

Ranks

	GROUP	N	Mean Rank	Sum of Ranks
nrs_baseline	1	24	44.17	1060.00
	2	71	49.30	3500.00
	Total	95		

Test Statistics[a]

	nrs_baseline
Mann-Whitney U	760.000
Wilcoxon W	1060.000
Z	-.813
Asymp. Sig. (2-tailed)	.416

a. Grouping Variable: GROUP

Tests of normality for maximal neck pain intensity at baseline

Ranks

	GROUP	N	Mean Rank	Sum of Ranks
neckpain_maxintens_baseline	1	24	44.81	1075.50
	2	71	49.08	3484.50
	Total	95		

Test Statistics[a]

	neckpain_maxintens_baseline
Mann-Whitney U	775.500
Wilcoxon W	1075.500
Z	-.661
Asymp. Sig. (2-tailed)	.509

a. Grouping Variable: GROUP

Tests of normality for average headache intensity at baseline

Ranks

	GROUP	N	Mean Rank	Sum of Ranks
headache_average_baseline	2	71	44.55	3163.00
	3	17	44.29	753.00
	Total	88		

Test Statistics[a]

	headache_average_baseline
Mann-Whitney U	600.000
Wilcoxon W	753.000
Z	-.037
Asymp. Sig. (2-tailed)	.970

a. Grouping Variable: GROUP

Tests of normality for maximal headache intensity at baseline

Ranks

	GROUP	N	Mean Rank	Sum of Ranks
headache_max_baseline	2	71	43.99	3123.50
	3	17	46.62	792.50
	Total	88		

Test Statistics[a]

	headache_max_baseline
Mann-Whitney U	567.500
Wilcoxon W	3123.500
Z	-.385
Asymp. Sig. (2-tailed)	.700

a. Grouping Variable: GROUP

Tests of normality for pain extent at baseline

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	GROUP	Statistic	df	Sig.	Statistic	df	Sig.
pain_extent_total_baseline	1	.088	23	.200*	.959	23	.441
	2	.135	66	.004	.835	66	<.001
	3	.247	10	.084	.786	10	.010

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Tests of normality for pain extent at follow-up

Tests of Normality

	GROUP	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
pain_extent_total_end	neck	.184	22	.050	.825	22	.001
	both	.171	63	<.001	.839	63	<.001
	head	.316	17	<.001	.638	17	<.001

a. Lilliefors Significance Correction

Tests of normality for neck pain intensity at baseline

Tests of Normality[b]

	GROUP	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
nrs_baseline	neck	.264	24	<.001	.867	24	.005
	both	.248	71	<.001	.860	71	<.001

a. Lilliefors Significance Correction

b. There are no valid cases for nrs_baseline when GROUP = 3.000. Statistics cannot be computed for this level.

Tests of normality for neck pain intensity at follow-up

Tests of Normality[b]

	GROUP	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
nrs_end	neck	.168	23	.092	.895	23	.020
	both	.141	71	.001	.906	71	<.001

a. Lilliefors Significance Correction

b. There are no valid cases for nrs_end when GROUP = 3.000. Statistics cannot be computed for this level.

Tests of normality for NDI scores at baseline

Tests of Normality[b]

	GROUP	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
ndi_total_baseline	neck	.220	24	.004	.883	24	.010
	both	.111	71	.031	.930	71	<.001

a. Lilliefors Significance Correction

b. There are no valid cases for ndi_total_baseline when GROUP = 3.000. Statistics cannot be computed for this level.

Tests of normality for NDI scores at follow-up

Tests of Normality[b]

	GROUP	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
ndi_total_adjusted_end	neck	.159	24	.118	.867	24	.005
	both	.162	71	<.001	.900	71	<.001

a. Lilliefors Significance Correction

b. There are no valid cases for ndi_total_adjusted_end when GROUP = 3.000. Statistics cannot be computed for this level.

Tests of normality for HIT-6 scores at baseline

Tests of Normality[a]

	GROUP	Kolmogorov-Smirnov[b] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
hit_total_baseline	2	.085	70	.200*	.977	70	.214
	3	.140	17	.200*	.974	17	.884

*. This is a lower bound of the true significance.

a. There are no valid cases for hit_total_baseline when GROUP = 1.000. Statistics cannot be computed for this level.

b. Lilliefors Significance Correction

Tests of normality for HIT-6 scores at follow-up

Tests of Normality[a]

	GROUP	Kolmogorov-Smirnov[b] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
hit_total_end_adjusted	2	.159	71	<.001	.923	71	<.001
	3	.315	17	<.001	.795	17	.002

a. There are no valid cases for hit_total_end_adjusted when GROUP = 1.000. Statistics cannot be computed for this level.

b. Lilliefors Significance Correction

Tests of normality for headache frequency at baseline

Tests of Normality[a]

	GROUP	Kolmogorov-Smirnov[b] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
headache_frequency_baseline	both	.242	71	<.001	.735	71	<.001
	head	.298	17	<.001	.547	17	<.001

a. There are no valid cases for headache_frequency_baseline when GROUP = 1.000. Statistics cannot be computed for this level.

b. Lilliefors Significance Correction

Tests of normality for headache frequency at follow-up

Tests of Normality[a]

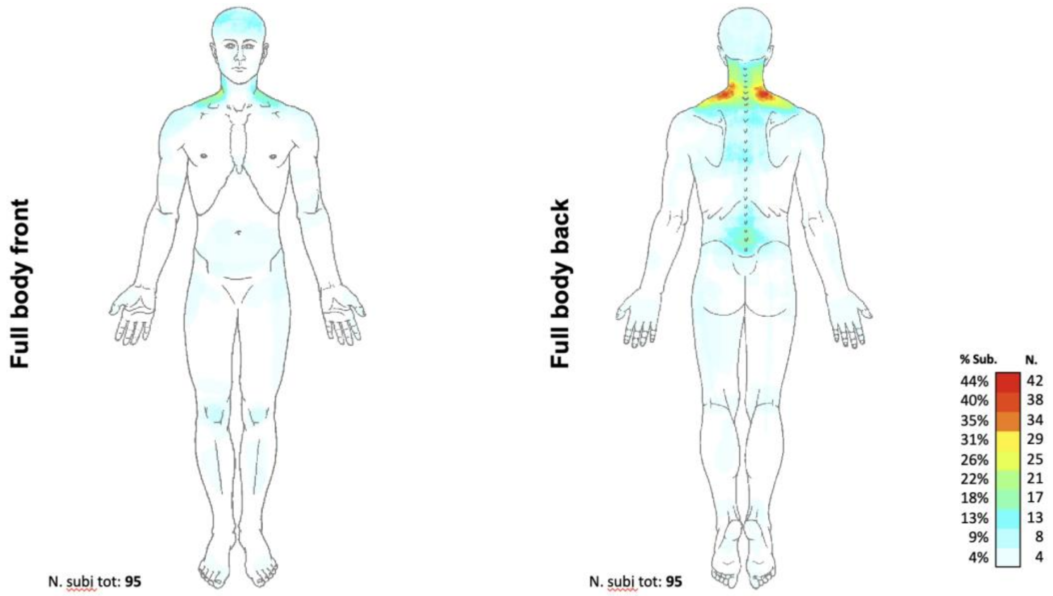
	GROUP	Kolmogorov-Smirnov[b] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
headache_frequency_end	both	.229	71	<.001	.746	71	<.001
	head	.294	17	<.001	.609	17	<.001

a. There are no valid cases for headache_frequency_end when GROUP = 1.000. Statistics cannot be computed for this level.

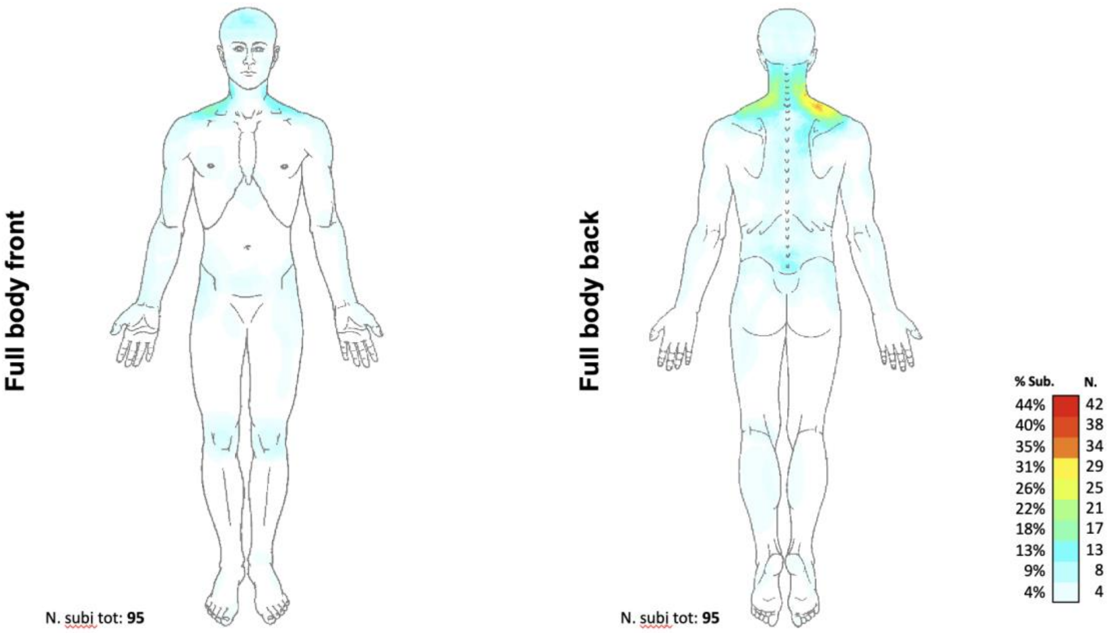
b. Lilliefors Significance Correction

Appendix 2

Pain frequency maps, at baseline, of all the participants from the original study.



Pain frequency maps, at follow-up, of all the participants from the original study.



(Darker shades represent a greater percentage of participants reporting pain in that location.)