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Neck pain and work productivity in office workers: Effectiveness of a multi-component intervention

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Note: Please refer to the Glossary on page 67 for a definition of all terms marked with an asterisk (*).

1. Abstract

Background and aim

Neck pain is a major burden for office workers, leading to discomfort and decreased work productivity. As the current literature does not provide a convincing approach to address this problem, the need to develop an effective intervention to reduce neck pain and associated productivity loss in office workers became evident. Furthermore, it remained unclear whether neck pain had changed in response to the COVID-19 pandemic and increased working from home. The aim of this thesis was therefore to design a cluster randomized controlled trial with a 12-week multi-component intervention (publication 1) and to investigate the effect of this intervention on reducing neck pain-related work productivity losses in office workers (publication 2). In addition, a sub-analysis examined the effect of the COVID-19 pandemic (i.e., working from home) on neck pain intensity and neck disability (publication 3).

Methods

We conducted a stepped-wedge cluster randomized controlled trial between January 2020 and April 2021. Office workers aged 18 to 65 years and without serious neck pain were recruited from two German-speaking organizations in Switzerland. During the 12-week intervention period, office workers participated in neck exercises, health-promotion information group workshops, and applied best practice workstation ergonomics. No intervention was offered during the control period. Neck pain-related loss of work productivity was assessed at five different measurement time points using the Work Productivity and Activity Impairment Questionnaire. Loss of work productivity was expressed as percentage of working time and converted into weekly monetary values. Additional information (e.g., COVID-19 pandemic-related data) was collected as part of the survey. For statistical analysis, (generalized) linear mixed-effects models were fitted to the data.

Results

A total of 120 office workers participated, the majority of them were women (71.7%) with a mean age of 43.7 years (SD 9.8). About 80% of office workers reported neck pain at baseline and neck pain-related loss of work productivity was 12% of working time. The intervention was able to reduce neck pain-related loss of work productivity by a marginal predicted mean of 2.8 percentage points (b = -0.27; 95% CI: -0.54 to -0.001, p = 0.049). The costs saved amounted to 27.40 Swiss Francs per participant per week. Our sub-analysis among participants in the control period of the study showed no clinically relevant effect of the COVID-19 pandemic (i.e., working from home) on neck pain intensity (b = -0.68; 95% CI: -1.35 to 0.00, p = 0.05) or neck disability (b = -0.05; 95% CI: -3.68 to 3.59, p = 0.98).

Conclusion

The effectiveness of a multi-component intervention in improving neck pain-related work productivity was confirmed by our study, with implications for multiple stakeholders. This is despite the adaptations of the original study design due to the COVID-19 pandemic. In addition, individual factors (e.g., physical activity, capabilities, motivation) and organizational factors at work (e.g., number of breaks or hours spent at the computer) seem to have a stronger impact on neck pain than the actual place of work.

2. Introduction

2.1. The burden of neck pain in office workers

With the shift from manufacturing to the service sector at the beginning of the 20th century, neck pain has become one of the most common musculoskeletal disorders worldwide [1, 2]. The global age-standardised point prevalence of neck pain is currently up to 3551.1 cases per 100,000 population [3], with an annual incidence of 806.6 per 100,000 population [3]. In detail, neck pain is among the most frequently reported complaints in Western Europe [4] and in the occupational group of office workers [5]. In Switzerland, for example, more than two-thirds of office workers report at least one day with neck pain a year [6].

In terms of consequences, neck pain not only affects individuals, e.g., through reduced quality of life or increased disability and pain [2], but also society, e.g., through direct and indirect costs. Direct costs include the treatment of neck pain, such as diagnostics or medication, and amount up to 3.8 billion Swiss Francs (CHF) per year in Switzerland [7]. Indirect costs, in contrast, include the costs arising from the consequences of work productivity* losses. Work productivity loss can be divided into absenteeism* (health-related absence from work [8]) and presenteeism* (working despite of health-related problems [8]) and amounts up to CHF 7.5 billion per year in Switzerland [7].

In summary, neck pain among office workers is not only becoming a major problem for the individual, employer, and health system, but also an economic burden for the society [1, 2]. Combined with the expected growth of the service sector in the 21st century (i.e., knowledge workers), the working from home, the high recurrence rate of neck pain (i.e., up to 75% within the first five years after onset [2, 9]), and the high risk for persistent pain [2, 10], neck pain in office workers presents a high burden that needs to be addressed in research.

2.2. Causes and risk factors for neck pain in office workers

In the majority of cases in which neck pain occurs, no specific cause (i.e., a fracture) can be found [11]. In these so-called nonspecific cases of neck pain, several modifiable and nonmodifiable factors may contribute – individually or in combination – to the development of neck pain. First, there are biological and personal risk factors such as advanced age [3, 12], female gender [5, 12-16], physical inactivity [5, 12, 13, 15], low capacity of the neck and shoulder muscles (i.e., endurance of neck flexors) [1], self-perceived high muscle tension [17], poor neck and head posture [1], reduced range of motion (e.g., of the cervical spine) [14], personal traits [4], and individual behaviour [4]. Some literature even suggests that the development of neck pain may be genetic [4]. Second, psychological factors such as pain-related behaviour [4], pain catastrophizing [18], fear-avoidance beliefs [4], low self-efficacy [19], and (work) stress conditions [5, 13-15, 18] may lead to neck pain in office workers. Interestingly, women tend to have more personal stressors and fewer occupational stressors compared to men [20]. Third, work-related risk factors such as sedentary work [12], low task variation [17], long hours of computer work [14, 15, 21], high job demands [10, 21], job insecurity [22], being in a leadership position [14, 23], poor workplace environment [13, 17], and ergonomic demands [17, 21] contribute to neck pain in office workers. Finally, many other risk factors have been described, such as sleep quality and social support [4, 19, 21]. Not surprisingly, the risk factors for developing neck pain are largely identical to the risk factors for lost work productivity due to neck pain [23-25].

2.3. Current treatment of neck pain in office workers

Current treatment approaches aim to reduce risk factors that contribute to the development of neck pain and neck pain-related work productivity loss in office workers. Among the most investigated are exercises, workstation ergonomics, and health-promotion information.

Exercises

Exercise intervention refers to physical training and/or physical activity designed to maintain or improve health. The underlying mechanism of exercise intervention is the adaption of personal and biological factors, such as muscle function or strength, to the demands of everyday (work) life [26, 27]. Two reviews concluded that exercise is only minimally effective in preventing musculoskeletal pain in office workers [28, 29], while two systematic reviews and meta-analyses found evidence that exercise reduces existing musculoskeletal pain [30, 31]. Among the most effective and recommended types of exercise are strengthening exercises [27, 29-40], especially neck-specific resistance training compared to general resistance training [28, 31]. This is followed by endurance exercises [29, 38], general physical fitness training [28, 31, 34, 41, 42], and stretching and flexibility exercises [27, 28, 31, 43, 44]. In contrast, a quasi-experimental trial and a randomized controlled trial (RCT) found no effect of exercise on musculoskeletal complaints [45, 46]. In terms of health economic outcomes, some studies reported an improvement of work productivity [32, 47], work ability* [48], and absenteeism [47] with exercise intervention, while others found no difference in sick leave* [46, 49].

Workstation ergonomics

Workstation ergonomics refers to the setup and use of the workstation according to ergonomic principles and guidelines. It affects biological and work-related factors in a similar way as exercises. For instance, the position of the cervical spine depends on the height of the monitor, desk, and chair. Therefore, the most studied adjustments include changes and adaptions to the keyboard, mouse, monitor, and armrests [31]. Tailored workstation adjustments have shown low quality evidence in reducing musculoskeletal symptoms [50, 51] and neck pain [31, 37, 52] in office workers. Similar to the effects of neck exercises, conflicting results have been reported for a preventive effect of workstation ergonomics [31]. In relation to neck pain-related work productivity, mixed findings for a change in work ability [51], work productivity [53], and sickness absence* [49, 50] were shown for workstation ergonomics. Despite the conflicting evidence and high costs of workstation adjustments, optimal workstation ergonomics remains among the most recommended interventions.

Health-promotion information

Health-promotion information is an umbrella term for a wide range of interventions that target physical, psychological, social, and work-related factors of the individual [54]. They aim to change health-related behaviour and general health-related aspects. No differences were found for changes in the prevalence or severity of neck pain for various health-promotion interventions, such as mental and physical health education, job stress management, and coping and behaviour change techniques [26, 27, 31]. In contrast, low-quality evidence was found for work breaks to reduce neck discomfort [31, 52].

With regard to neck pain-related work productivity, participation in a health-promotion intervention program was on the one side associated with improvements in work productivity [55], work ability [48], and work performance * [56], and on the other side with a reduction in sickness absence [49, 55-58], absenteeism [55], and presenteeism [59]. However, the heterogeneity of health-promotion information programs used in the studies (i.e., in terms of duration and types) makes it difficult to compare different programs and draw conclusions.

Combined approaches

In addition to single interventions, combined approaches have also been tested. Three cluster RCTs [60-62] examined the effect of a 12-week combined ergonomics and health-promotion information intervention compared to a combined ergonomics and strength exercise intervention. After 12 weeks, the exercise group had less neck pain than the health-promotion group [62]. However, this effect disappeared after 12 months [62]. Ting et al. [61] found no difference in work ability between the groups, while Pereira et al. [60] observed lower presenteeism and higher work productivity at 12 months in favour of the exercise group compared to the control group. Consistent with this, an RCT comparing exercise with health-promotion information showed a decrease in neck pain intensity with exercises, but there was no difference in sick leave [63]. In addition, a combination of exercises and health-promotion information led to a greater reduction in neck pain than health-promotion information alone [64]. Another study investigated the effect of exercises compared to ergonomics and a control group [65]. A difference in neck pain was only found between the control group and the exercise group, but not for the ergonomics group [65]. A recent systematic review and meta-analysis [66] concluded similarly: exercises improved shoulder pain, while the results for ergonomics were mixed.

2.4. Recommendations for the implementation of workplace health interventions

Besides the choice of the treatment approach, questions arise about the implementation process. For workplace health interventions in general, higher effect sizes are found with higher adherence to the intervention [31]. In line with the propositions of the conceptual framework of the Behaviour Change Wheel [67], higher adherence to the intervention can be achieved by techniques that improve office workers' capabilities and motivation, for example by providing supervision [39, 68-70], instruction, demonstration (e.g., videotapes of the exercises) [71, 72], and goal setting [72, 73]. Moreover, adherence can be improved by changes in office workers' physical and social environment to create better opportunities, for instance by offering interventions during working hours [68, 70], at the workplace [68], and by establishing social support. For exercise intervention, in detail, the literature recommends performing exercises for at least ten weeks [31, 39, 74], with one hour of training per week [31, 35], and regular progression of exercises [40]. Surprisingly, the type of exercise was not a determining factor [71]. Despite these recommendations, adherence to the intervention, especially over the long-term, has been identified as a key problem in current research and practice [28, 75].

In addition to individual barriers, barriers to implementing an intervention are often related to the context [76]. For example, medium to large organizations are preferrable as they have more resources available [68]. Another factor for a successful and sustainable implementation of an intervention is the organizational readiness for change [77].

2.5. Summary and research gap

There is already a considerable amount of literature examining single or combined interventions and their effect on neck pain and associated work productivity loss in office workers. In summary, the success of the intervention depends partly on the cause of the neck pain, which is often multifactorial. Attempts have already been made to address this aspect with single and/or tailored interventions, but these were hardly feasible and implementable in the heterogenous population of office workers and showed only small to medium effect sizes [59, 78]. Similarly, approaches combining two interventions also achieved small effect sizes and were very time-consuming [47, 60]. Furthermore, interventions designed to reduce neck pain did not necessarily improve neck-pain related work productivity (and vice versa). It therefore remains unclear which treatment approach is preferable for reducing neck pain and associated work productivity loss in office workers. However, system-oriented interventions have been described as more effective than patient-oriented ones [79].

Besides the choice of the treatment approach, it is crucial to carefully consider the implementation strategies that will be used. In particular, it should be noted that higher participation in the intervention seems to improve the outcome [60, 74, 80]. However, adherence to the intervention is still a fundamental problem in current studies and in practice and could be one of the reasons for small effect sizes [47, 60].

In addition to the gaps in current research, there is an unmet need among different stakeholders. At the organizational level, there is a need for a (cost-) effective intervention to address office workers' neck pain (e.g., to optimally manage limited financial resources for health initiatives). Individuals, their workplace, private and public policy, and practice are also interested in health-promoting behaviours for office workers, given the amount of time spend at work and the link between health, work, and productivity [81, 82].

In conclusion, a new approach to the treatment of neck pain and neck pain-related work productivity loss in office workers is urgently required. In contrast to previous studies, this new approach should combine the following key characteristics for successful and sustainable intervention design and implementation: Addressing multifactorial causes of neck pain in a heterogenous sample of office workers, achieving high adherence to the intervention, obtaining a large effect size by applying system-oriented interventions and strategies, and reducing both neck pain and neck pain-related loss of work productivity. The idea of our research group was therefore to combine existing evidence-based and best practice interventions, i.e., neck exercises, workstation ergonomics, and health-promotion information, and to investigate their combined effect (i.e., additive, multiplicative) on neck pain and neck pain-related work productivity.

2.6. Development and design of the project

Based on this idea, we developed the Swiss National Science Foundation project "On-Site Multi-Component Intervention to Improve Productivity and Reduce the Economic and Personal Burden of Neck Pain in Swiss Office-Workers" (short version: neck exercise for productivity, NEXpro). This thesis comprises the following three publications including one manuscript, all of which were written within the NEXpro project.

Study protocol

The first publication within this thesis is the study protocol, which addresses the development and design of the NEXpro project and RCT [54, 83]. In planning the project, emphasis was placed on the findings and recommendations from previous literature, particularly the cluster RCTs by Ting et al. [61] and Welch et al. [75].

The overall aim of the NEXpro project was to investigate the effect of a new approach – an on-site multi-component intervention – on neck pain-related work productivity loss among office workers. For this purpose, a stepped-wedge cluster RCT with unidirectional crossover between control and intervention condition was conducted [84]. The RCT started in January 2020 with an expected duration of one year. A total of 120 office workers from Switzerland were included, all of whom had sedentary jobs, were of working age (18 to 65 years of age) and had neck pain or wanted to prevent it. The intervention lasted 12 weeks and was a combination of neck exercises, health-promotion information group workshops, and individually workstation ergonomic interventions. No intervention took place during the control period. The primary outcome was neck pain-related work productivity loss, quantified with the validated Work Productivity and Activity Impairment Questionnaire for Specific Health Problem (WPAI) [85]. Secondary outcomes not reported in this thesis include neck pain (i.e., neck disability, neck pain intensity and frequency). For statistical analysis, general linear mixed effects models were fitted to the data.

Multi-component intervention and neck pain-related work productivity loss

The second manuscript deals with the primary outcome of the NEXpro trial: the effect of our on-site multi-component intervention on neck pain-related work productivity loss in office workers. We hypothesized that the multi-component intervention would be effective in reducing neck pain-related work productivity loss.

Neck pain and working from home

The NEXpro project had to be adapted because of the coronavirus disease 2019 (COVID-19) pandemic. Due to the recommendation to work from home, the intervention was conducted online instead of on-site. In addition, the intervention period was postponed during the COVID-19 lockdown in spring 2020, which extended the total duration of the RCT by four months. This short interruption provided an opportunity for an initially unplanned sub-analysis within the NEXpro project. Another and more crucial driving force for the third publication was the increased public interest and unprecedented research questions on neck pain in office workers caused by the increase in working from home [86, 87]. The aim of this publication was therefore to examine the effect of the COVID-19 lockdown (i.e., working from home) on neck pain intensity and neck disability [88]. The analysis was based on control group data from the NEXpro project and by comparing data before the COVID-19 lockdown (baseline measurement in January 2020) with data during the first COVID-19 lockdown (follow-up 1 measurement in April 2020). Our research group hypothesized that neck pain intensity and neck disability changed (i.e., increased) during the COVID-19 lockdown. This was tested by fitting two linear mixed-effects models to the data, using neck pain intensity and neck disability as criterion variables and the number of work breaks, hours of computer work, workstation ergonomics, and measurement time point as predictors.

3. Proof of Publication

3.1. Study protocol

On-site multi-component intervention to improve productivity and reduce the economic and personal burden of neck pain in Swiss office-workers (NEXpro): protocol for a cluster-randomized controlled trial

Status: Published (19.06.2020), Correction (25.07.2020)

Journal: BMC Musculoskeletal Disorders. 2020;21(1):391.
DOI: 10.1186/s12891-020-03388-x
BMC Musculoskeletal Disorders. 2020;21(1):488.
DOI: 10.1186/s12891-020-03507-8

3.2. Multi-component intervention and neck pain-related work productivity loss

A multi-component intervention (NEXpro) reduces neck pain-related work productivity loss: A randomized controlled trial among Swiss office workers

Status: Under review (submission: 04.02.2022)

Journal: Journal of Occupational Rehabilitation

3.3. Neck pain and working from home

No evidence for an effect of working from home on neck pain and neck disability among Swiss office workers: Short-term impact of COVID-19

Status: Published (04.04.2021)

Journal: European Spine Journal. 2021;30(6):1699-1707.
DOI: 10.1007/s00586-021-06829-w

4. Publications

4.1. Study protocol

Publication

The publication entitled "On-site multi-component intervention to improve productivity and reduce the economic and personal burden of neck pain in Swiss office-workers (NEXpro): protocol for a cluster-randomized controlled trial" [54], including correction [83], is available on the next pages.

Contribution

Andrea Martina Aegerter (AMA) and Manja Deforth (MD) contributed equally to the study protocol. Communication with the authors and the journal during the submission, review, and publication process was handled by AMA. More detailed information on the contributions of each author can be found in the corresponding chapter of the publication of the study protocol. Additional work related to this publication is described in the following. Prof. Dr. med. Markus Melloh (MM), Prof. Dr. phil.-nat. Achim Elfering (AE), Prof. Dr. Thomas Volken (TV), and Prof. Dr. med. Julia Dratva (JD) designed the study and wrote the funding application in consultation with Dr. Beatrice Brunner (BB), Prof. Dr. phil. Hannu Luomajoki (HL), Prof. em. Dr. Gisela Sjøgaard (GS) and Assoc. Prof. Dr. Venerina Johnston (VJ). In addition, two students from the University of Bern conducted a feasibility study as part of their master's thesis, which provided additional insights for the outline of the NEXpro trial. The detailed planning of the intervention was done by AMA and MD in consultation with HL (neck exercises), Markus Josef Ernst (MJE, neck exercises), GS (neck exercises), AE (health-promotion information), VJ (health-promotion information and workstation ergonomics), and Dr. Corinne Nicoletti (CN, workstation ergonomics). AMA was responsible for the neck exercises, smartphone application, and workstation ergonomics. MD was in charge of the health-promotion information group workshops. Instruments for measurement were selected by AMA, MD, ME, AE, and MM in consultation with BB, VJ, GS, CN, Prof. Dr. med. Oliver Distler (OD), and Prof. Dr. med. Holger Dressel (HD).

AMA and MD drafted the ethics application and registered the trial under the supervision of MM and AE. MM led the recruitment of the two organizations and was assisted by AMA, MD, Irene Etzer-Hofer (IE), and CN.

Licence

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BMC Musculoskeletal Disorders

STUDY PROTOCOL Open Access

On-site multi-component intervention to improve productivity and reduce the economic and personal burden of neck pain in Swiss office-workers (NEXpro): protocol for a cluster-randomized controlled trial

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Abstract

Background: Non-specific neck pain and headache are major economic and individual burden in office-workers. The aim of this study is to investigate the effect of a multi-component intervention combining workstation ergonomics, health promotion information group workshops, neck exercises, and an app to enhance intervention adherence to assess possible reductions in the economic and individual burden of prevalent and incident neck pain and headache in office workers.

(Continued on next page)

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Methods/design: This study is a stepped wedge cluster-randomized controlled trial. Eligible participants will be any office-worker aged 18–65 years from two Swiss organisations in the Cantons of Zurich and Aargau, working more than 25 h a week in predominantly sedentary office work and without serious health conditions of the neck. One hundred twenty voluntary participants will be assigned to 15 clusters which, at randomly selected time steps, switch from the control to the intervention group. The intervention will last 12 weeks and comprises workstation ergonomics, health promotion information group workshops, neck exercises and an adherence app. The primary outcome will be health-related productivity losses (presenteeism, absenteeism) using the Work Productivity and Activity Impairment Questionnaire. Secondary outcomes are neck disability and pain (measured by the Neck Disability Index, and muscle strength and endurance measures), headache (measured by the short-form headache impact test), psychosocial outcomes (e.g. job-stress index, Fear-Avoidance Beliefs Questionnaire), workplace outcomes (e.g. workstation ergonomics), adherence to intervention, and additional measures (e.g. care-seeking). Measurements will take place at baseline, 4 months, 8 months, and 12 months after commencement. Data will be analysed on an intention to treat basis and per protocol. Primary and secondary outcomes will be examined using linear mixed-effects models.

Discussion: To the authors' knowledge, this study is the first that investigates the impact of a multi-component intervention combining current evidence of effective interventions with an adherence app to assess the potential benefits on productivity, prevalent and incident neck pain, and headache. The outcomes will impact the individual, their workplace, as well as private and public policy by offering evidence for treatment and prevention of neck pain and headache in office-workers.

Trial registration: ClinicalTrials.gov, NCT04169646. Registered 15 November 2019 - Retrospectively registered.

Keywords: Occupational health, Workplace, Neck pain, Health promotion, Exercise, Patient compliance, Ergonomics, Efficiency, Randomized controlled trial, Adherence

Background

Non-specific neck pain (NP) is a major burden in industry due to lost productivity in terms of absenteeism and presenteeism as well as personal suffering from pain, disability, or reduced quality of life [1]. Moreover, NP has a high tendency for persistence and recurrence [1]. In 2010, a Swiss federal directive indicated that 68% of office-workers experienced NP on at least 1 day per year, while a recent study examining representative Zurich-based young and middle-aged adults indicates NP prevalence between 18 and 55%; both percentages appear at the upper end of global estimates [2, 3]. In another study, 13% of symptomatic office-workers reported reduced work productivity due to NP of nearly 22% [4].

In a Swiss survey, 35% of more than twelve thousand office-workers complained about having at least one headache episode within the last 4 weeks [3]. The 12-month-population prevalence for headache was approximately 34% for Switzerland, leading to a second rank for all health-related complaints [5]. In women in particular, headache ranked first in Switzerland (37%) [5]. These figures have been confirmed by a European census including 27 states ($n = 28{,}079$), which also comprises data from Switzerland ($n = 871$). However, these data relate not only to office-workers [5].

The workplace is increasingly becoming the arena for many health initiatives not only because of the amount of time an individual spends at the workplace, but also due to the strong link between work and health, and between health and productivity [6, 7]. Most current workplace-based strategies for the prevention and management of NP in office-workers fall into two broad categories: ergonomic-based interventions targeting the workstation or environment, and exercise-based interventions targeting the workers' capacity to do their job [8, 9]. Recent studies examined the effect of workplace ergonomics, neck exercise, or health promotion on the individual burden of pain and disability as summarized below.

Three studies showed a positive effect of an ergonomic intervention on economic burden (productivity), but no effect on the individual burden of pain or disability [10–12]. A systematic review and meta-analysis by Chen et al. [13] questioned the value of stand-alone workstation ergonomic interventions in the office for people with NP which, is supported by strong evidence of no effect. One study was in favour of a multi-component ergonomic intervention, and another in favour of low monitor angles [14, 15]. Despite this contradictory and underwhelming evidence supporting workstation ergonomics, it is generally considered best practice for the work environment and most companies now provide workstations that can be adjusted to suit each employee [16]. However, a worker's use or non-use of these often expensive items has not been sufficiently explored.

Health promotion is a broad field inclusive of interventions targeting the physical and psychosocial aspects of the individual and the workplace. Two systematic reviews showed a positive effect of health promotion intervention on work productivity [17, 18].

Exercise is a common treatment for office-workers suffering from musculoskeletal disorders [19, 20]. Likewise, in office-workers exercises may alleviate headache [21]. A systematic review and meta-analysis showed that strengthening exercises should be favoured to endurance and stretching exercise for the treatment of NP in office-workers [22]. An Australian study examined the impact of neck exercises on workplace productivity in monetary terms specific to office-workers within participating companies [23]. This study found evidence that neck strengthening exercises and best-practice ergonomics positively influence productivity and pain [23]. Other recent studies show improved productivity with exercise-based interventions [24–28].

Independent of the mode of the intervention (neck exercise, workstation ergonomics, health promotion), adherence to an intervention still remains a huge problem. Different studies observed greater effect with higher participation, which points to a need for an intervention that additionally encourages adherence [23, 29, 30]. A way to enhance exercise adherence is the use of an exercise app [31]. Main benefits of an app are the constant availability of the exercise program and an interactive technology with feedback and reminder.

To the authors' knowledge, no research project has investigated the effect of a multi-component intervention, that includes all current evidenced aspects, and tested it against 'as usual' practise to assess the economic burden (work productivity) of prevalent and incident NP. Thus, the aim of this study is to investigate the impact of a multi-component intervention for office-workers that combines the evidence-based interventions of workstation ergonomics, health promotion, neck exercise, and an app to enhance adherence to intervention with regard to productivity, prevalent and incident NP, and headache. The overarching hypothesis is that work productivity will be improved by empowering workers to reduce NP- and headache-related presenteeism and absenteeism. Furthermore, NP, headache and/or disability (primary and secondary prevention) will be reduced and job stress and health-related quality of life will be improved.

Methods / design

Study design

A stepped wedge cluster-randomized controlled trial (RCT) with a multi-component intervention group is planned for 2020. In a stepped wedge cluster RCT, each participant completes a control and intervention period [24, 32].

This study protocol was written according to the SPIRIT (Standard Protocol Items for Randomized Trials) recommendations [33].

Participants

Study setting and eligibility criteria

Participants will be recruited from two Swiss organisations in the Cantons of Zurich and Aargau towards the end of 2019. Inclusion criteria will be Swiss office-workers, who suffer from NP or want to take prevention of neck pain or headache, aged 18–65 years, working more than 25 h per week (0.6 full-time equivalent) in predominantly sedentary office work and have provided written informed consent. In addition, participants will have to be able to communicate in German (written, spoken). Exclusion criteria are in alignment with European taskforce (EUTF) recommendations and will be health conditions such as previous trauma or injuries to the neck (NP grade 4 [34]), specific diagnosed pathologies (e.g., congenital cervical abnormalities stenosis, fracture, radiculopathy) or inflammatory condition (e.g., rheumatoid arthritis), any history of cervical spine surgery or if exercise is contraindicated (e.g., medical advice, own beliefs) [35]. Participants who anticipate prolonged absence from work (more than four consecutive weeks) during the study intervention period and / or pregnant women will be excluded.

Recruitment

The project coordinator will distribute information (e-mail, flyer, announcement) to participating organisations to forward to employees. To enhance recruitment, short presentations about the study will be offered as required in each organisation. Employees willing to participate will be directed to the study website for further information about the research and to register their interest. Screening of interested employees will be completed in person.

Allocation to cluster and group

The project coordinator will allocate eligible participants to a cluster (de-identified) until the required number is reached for each intake. A senior statistician blinded to the identity of individuals will randomise clusters to a sequence within the period of data collection when clusters change from the control to the intervention condition (group 1 to 3). A cluster is defined as a group of seven office-workers located on the same floor, room or work group. Fifteen clusters will be required to achieve a sample size of 120. The study coordinator will notify individuals of their allocation, collect baseline data, and communicate between participants and the intervention health professional to organize assessments.

Timeline

The study duration for each participant is approximately 1 year. After recruitment, screening, and confirmation of eligibility, clusters will be randomly assigned to the groups. The study intervention will start according to their cluster affiliation (Fig. 1). Every 16 weeks, they will be asked to complete follow-up assessments including online-surveys and physical examinations. Each participant will receive the intervention within their cluster at the time point scheduled by the randomization procedure.

Intervention

The multi-component intervention will last for 12 weeks and will combine four existing evidence-based interventions. Each participant will receive all four interventions.

- *Workstation ergonomics:* Participants' workstation ergonomics will be assessed using an observation-based ergonomics assessment checklist for office-workers adapted to Swiss guidelines [36]. Based on the initial assessment, best practice ergonomics will be applied individually using existing infrastructure [23]. Topics will include for example the adjustment of the chair, desk, and monitor.
- *Health promotion:* Participants will attend health promotion information group workshops for approximately 1 h per week for 12 weeks. Content will include: attitudes to health and elements of success (including sleep); basic anatomical knowledge; behaviour change towards success; common workplace mental health issues; conflict management and resilience in the workplace; job stress and how to deal with it; keeping active (sit less, move more); keeping up the momentum and motivation; practical healthy eating; role of digital media; self-esteem; stress and relaxation workshop; and text-neck and how to avoid it [23, 37]. 'Text-neck' describes mechanical exposures on the neck, including static loading, non-neutral postures, and repetitive motions, associates with viewing portable devices over prolonged periods of time. The topics were selected in consultation with the organisations and on the basis of previous studies [23].
- *Neck exercise:* Participants will receive an individual progressive exercise programme aimed at conditioning the muscles of the neck and shoulder girdle. The exercises will be performed in groups (maximum of 12 per group) at the workplace in a dedicated room, for approximately 1 h (3 × 20 minutes) per week; once per week supervised by a physiotherapist, a human movement scientist, or a health scientist, and twice per week self-administrated. A standard sequence of exercises will be prescribed to all participants, but their implementation and progression will be within the specific capabilities of the individual considering potential age- and gender-specific requirements. Participants will perform shoulder girdle exercises (bilateral shoulder shrugs; bilateral scapular raise; bilateral incline shoulder external rotation in squat position; bilateral shoulder extension; shoulder row; bench dips; incline push-ups), progressing from un-resisted to resisted utilising variable resistance bands, and neck exercises (using the hand to apply resistance during neck flexion, extension and rotation) [38, 39]. Training load for each individual will be based on their one-repetition maximum (1-RM) that will be assessed during physical examination of the neck and regularly re-evaluated [40, 41]. Training sessions will start with ten repetitions at 50% of 1-RM warm-ups, followed by two to three sets of 10–15 repetitions of exercise at 60–80% of 1-RM corresponding to 10-RM. Adequate breaks will be taken between sets to avoid overexertion. Warm-up exercises (bilateral shoulder circling; upper body rotation) once each for 20 s, and cool-down exercises (lateral neck stretch; neck extensor stretch; seated side stretch; self-massage of shoulder and neck with spiky ball) for three times 20 s will complete the program [20, 42].
- *Adherence to intervention:* Workshop session attendance will be recorded as an indication of adherence to health promotion. Adherence to neck exercises will be recorded with the Physitrack® app (London, United Kingdom). Participants will maintain a record of exercise frequency, intensity, time, and type (F.I.T.T principles) [43]. A detailed instruction of each exercise technique (video), load intensity, and details regarding the number of sets and repetitions are recorded for each participant on the app enabled on their smartphone, tablet, or desk-top computer. Training reminder and feedback will be provided by the app.

Outcomes

Primary outcome

NP-related productivity loss (economic outcome) will be measured in percentages of the working time, using the Work Productivity and Activity Impairment Questionnaire for Specific Health Problem (WPAI-SHP, German version) and converted into monetary units using individual earnings [44–46].

The WPAI questionnaire is composed of five questions with a recall time frame of the past 7 days: Q1 = currently employed; Q2 = hours missed due to NP; Q3 = hours missed due to other reasons (e.g., vacation); Q4 = hours actually worked; Q5 = degree to which NP affected

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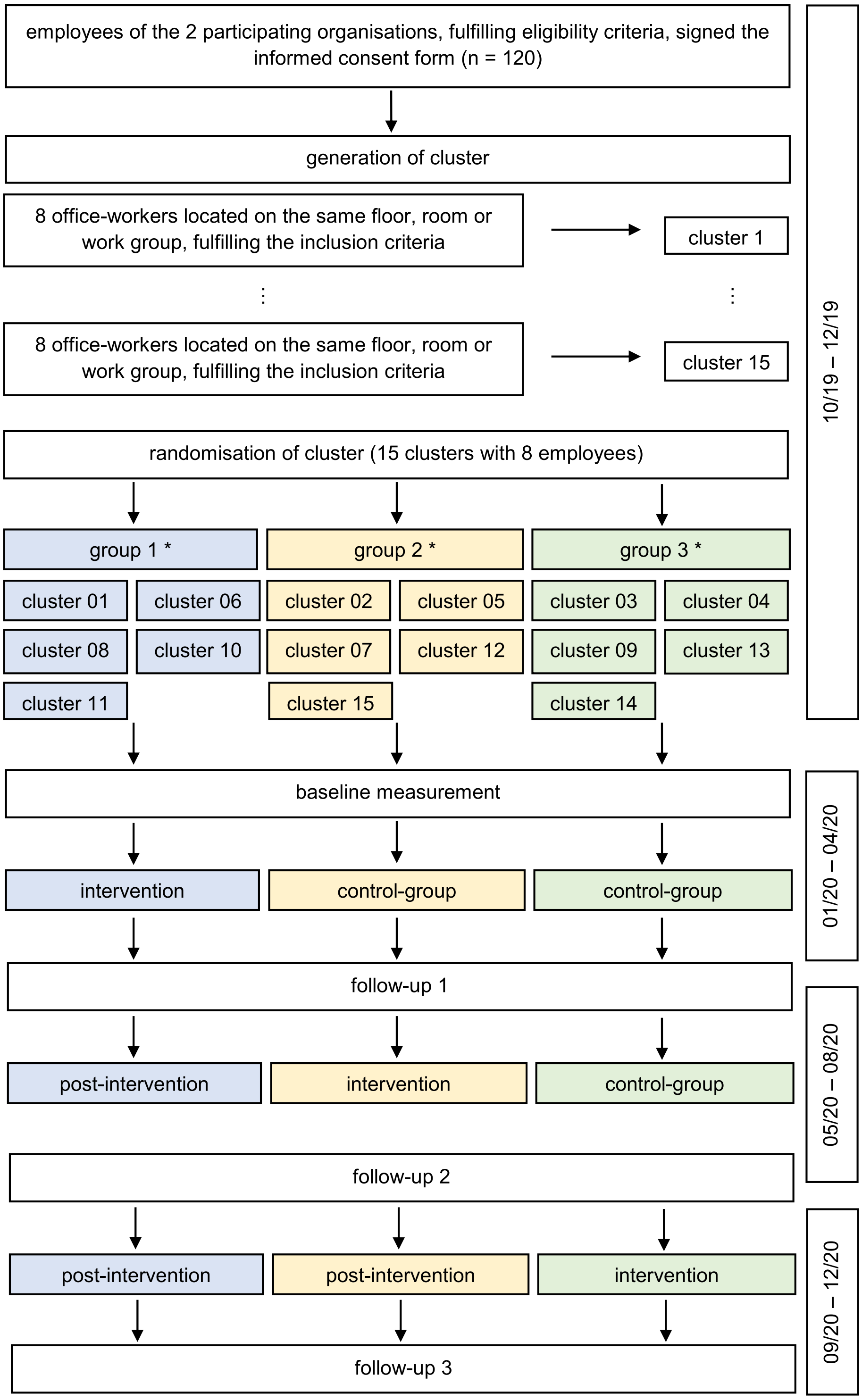

Fig. 1 Flow chart of study. Legend: * the affiliated cluster numbers are only examples

productivity while working (using a 0 to 10 Visual Analogue Scale) [47, 48].

NP-related impairment percentages will be calculated following the scoring rules of the developers of the WPAI (percentage absenteeism = Q2/(Q2 + Q4), percentage presenteeism = (1-Q2/(Q2 + Q4))*Q5/10)). The total NP-related work productivity loss is obtained by adding the percentage absenteeism and presenteeism (percentage NP-related work productivity loss = (Q2/(Q2 + Q4) + (1-Q2/(Q2 + Q4))*Q5/10) [47, 48]. The monetary value for the lost productivity will be calculated for each individual by multiplying the percentages by the individual gross wage [47, 48].

Secondary outcomes

Several secondary outcomes will be measured, which can be divided into the following subsections:

- *Physical and health outcomes* including self-assessment of NP and headache (extent / pain drawings, occurrence, frequency, intensity, duration, Neck Disability Index, short-form headache impact test), physical examination of the neck (muscle strength, muscle endurance, mobility, local pain pressure threshold), physical activity level (International Physical Activity Questionnaire) and health related quality of life (EuroQoL Five Dimension) [49–71].
- *Psychosocial outcomes* as the job-stress index, job satisfaction, and health beliefs (Fear-Avoidance Beliefs Questionnaire) [47, 72–74].
- *Workplace outcomes* as workstation ergonomics (observation-based ergonomics assessment checklist for office-workers adapted to Swiss guidelines), workplace implementation, psychosocial workplace factors (Copenhagen Psychosocial Questionnaire), work breaks, and daily use of personal smartphone [36, 75].
- *Adherence to intervention*

Additional measures

- *Participants' global impression of change* on an 11 points scale [74, 76].
- *Individual characteristics* (e.g. gender, care-seeking) are collected as predictor or control variable.

Data management

Study personnel

All measurements and interventions will be delivered by qualified and experienced health care professionals. Physiotherapists, health scientist, human movement scientists, and psychologists involved in data collection and delivering the interventions will receive prior training from nationally accredited experts in order to maintain standardised methodologies. A study on interrater reliability with the actual staff was conducted at the end of 2019.

Blinding

After assignment to the intervention condition, the administrators of online-surveys will be blinded to the identity of the individuals through an encoded login of participants. The outcome assessors of the physical examination will be blinded to group allocation and previous test results of the participants. Data analysts will be blinded to the identity of the individuals.

Data collection

Physical examination of the neck will be recorded in paper-based report forms, which will be digitalized afterwards. Data entry for electronic data will be double-checked for typos and missing data. UNIPARK© (Berlin, Germany) will be used for the online questionnaire.

Data analysis

The effect of the intervention in reducing the productivity loss over the study period will be examined using linear mixed-effects models, similar to the one used in the simulation-based power calculation. Moreover, the broader category of generalized linear mixed-effects models will be used for the analyses of secondary outcomes. We will also investigate the distribution of gender and symptom characteristics (like persistence) across different groups at baseline. In case of uneven distributions, these factors will be included in the model to adjust for their potential confounding effects. If required, we will also adjust for other potential confounding effects in the analyses, such as age, occupation, adherence, psychosocial factors, health beliefs, job satisfaction, and physical activity at baseline.

All statistical analyses will be performed using Stata® (Texas, USA) or R® (Boston, USA) statistical software. Significance level was set at alpha = 0.05. Missing data will be examined to determine its randomness and addressed with multiple imputations, if required. The results of the mixed-effects modelling will be presented in outcome specific effect sizes and their 95% confidence intervals. The data will be analysed on an intention to treat and per protocol basis. Drop-outs before study commencement will be replaced by recruitment of new subjects.

Data deposition and curation

All anonymized study data will be archived at Zurich University of Applied Sciences (ZHAW) for a minimum of 10 years after study termination or premature termination of the clinical trial on restricted data pools and fire-proofed lockers, respectively with access only by study personnel.

Sample size calculation

Based on the baseline results of an Australian study, we assumed a baseline productivity of 90% and an intervention attributable increase in productivity of 5% [23]. Also, in line with the Australian study, the cluster size was set to seven subjects. In order to test the sensitivity of the sample size calculations, we used varying cluster-specific and subject-specific intraclass correlations (Rho [1] = 0.1 or 0.2 and Rho [2] = 0.2 and 0.3 respectively) as well as varying number of steps (three or four steps). The underlying statistical model that was used in the simulations was a standard closed cohort mixed effects model comprising a random effect for the clusters, a random effect for the repeated measurements on the same cohort of individuals, a fixed effect to account for time trends, and a fixed effect representing the treatment effect [77, 78]. The linear mixed effect method from the R-package lme4 was used to estimate the models [79]. Furthermore, the acceptable probability for a Type I Error to occur was set to alpha = 0.05 and the acceptable probability for a Type II Error to occur was set to beta = 0.20 (Power = 0.80). From the four assessed scenarios, the solution with 72 participants, 12 clusters and three steps are optimal in the sense that three steps put much less burden on participants than four steps, i.e., there are less measurements per subject.

An Australian study reported an attrition rate of nearly 20%. In order to prevent the risk to under-power our study, we will increase the number of clusters from 12 to 15 (> 20%) and the number of subjects per cluster from 6 to 8 (> 20%) [23]. Consequently, we aim to enrol and follow 120 participants in 15 clusters over four measurements (one baseline and three steps from the control to the intervention arm of the study) which yields a total of 420 observations.

Discussion

Summary

NP is a major burden in Swiss office-workers. To the authors' knowledge, this study is the first that investigates the effect of a multi-component intervention combining the current evidence of workstation ergonomics, health promotion, neck exercises, and an adherence app to impact the economic and individual burden of NP and headache in this population.

Considerations and issues

Study design

As in many intervention studies, drop-outs and non-attendances are anticipated [13, 23]. Therefore, the sample size calculation is adjusted and adherence to intervention may be optimized using an app. In addition, the intervention will take place at the workplace and, depending on the organisation, almost the whole time needed for the intervention can be counted as working time. As not all participants will receive the intervention at the same time, a contamination of intervention may occur. To minimize this effect, people working on the same floor, in the same room or work group will be in the allocated to the same cluster.

Ethical approval

As every subject will eventually receive the intervention, ethical concerns of negligence should be regarded as unwarranted. The stepped wedge design helps to achieve a similar study power while requiring fewer participants, although more measurement from each [24, 32].

Safety

No risks of the intervention, except from some temporary muscle soreness due to the exercise intervention and testing have been reported in earlier studies [27, 29, 80]. Participants suffering from NP or headache may feel an immediate benefit during the study and not only during their working hours. These effects especially depend on adherence to the exercise programme, but also on the feedback to study personnel regarding any longer lasting discomfort or pain due to the interventional programme. A brief worsening of the symptoms may occur at the start of intervention period due to muscular change [38].

Monitoring and auditing

At minimum of four visits will be conducted by a monitor who is independent of the study (informed consent, data collection and case report forms, data entry, data analysis). Monitoring visits at the investigator's site prior to the start and during the course of the study will help to follow up the progress of the clinical study, to assure utmost validity of the data and to detect possible errors at an early time point.

Dissemination plan

After the statistical analysis of this trial, the NEXpro (neck exercise productivity) team will publish data in top-ranking journals in medicine and health sciences. In particular, the following publications beyond the study protocol are planned: primary outcome (productivity analysis), studies on secondary and additional outcomes (e.g., neck pain analysis, headache analysis).

Potential implication

It is expected that the study will impact the individual, their place of work, as well as private and public policy and practice regarding healthy behaviours of office-workers. This research will address an unmet organisational need by exploring the impact of an evidence-based intervention over the course of a year.

Abbreviations

AA: Andrea Aegerter; AE: Achim Elfering; BASEC: Business Administration System for Ethics Committees; BB: Beatrice Brunner; Dec: December; EuroQoL: European Quality of Life (Community); EUTF: European taskforce; Fig.: Fig; F.I.T.T. : Exercise principles (frequency, intensity, time, and type); GS : Gisela Sjøgaard; HL: Hannu Luomajoki; ICH-GCP: International Conference on Harmonisation-Good Clinical Practice; MD: Manja Deforth; ME: Markus Ernst; MM: Markus Melloh; NEXpro: Neck exercise productivity; NP: Neck pain; RCT: Randomized-controlled trial; SPIRIT: Standard Protocol Items for Randomized Trials; TV: Thomas Volken; VJ: Venerina Johnston; WPAI-SHP: Work Productivity and Activity Impairment Questionnaire for Specific Health Problem; ZHAW: Zurich University of Applied Sciences; 12-RM: Twelve-repetition maximum

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Authors' contributions

AA and MD wrote the study protocol. ME, HL, and BB revised the study protocol. VJ, GS, and AE designed the study and revised the study protocol. MM, JD, and TV wrote the funding application, designed the study and revised the study protocol. TV performed the sample size calculations, designed the statistical analysis and revised the study protocol. All authors read and approved the final manuscript.

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Availability of data and materials

Not applicable.

Ethics approval and consent to participate

This study has been approved by the Ethical Commission of the Canton of Zurich, Switzerland (swissethics No. 2019–01678). Written informed consent will be obtained from study participants.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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CORRECTION Open Access

Correction to: On-site multi-component intervention to improve productivity and reduce the economic and personal burden of neck pain in Swiss office-workers (NEXpro): protocol for a cluster-randomized controlled trial

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Correction to: BMC Musculoskelet Disord 21, 391 (2020)
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Following publication of the original article [1], an error occurred during production of the paper " On-site multi-component intervention to improve productivity and reduce the economic and personal burden of neck pain in Swiss office-workers (NEXpro): protocol for a cluster-randomized controlled trial" (BMC musculoskeletal disorders 21 (1):391. doi:10.1186/s12891-020-03388-x). The correct name in the NEXpro collaboration group and the acknowledgements should be "Holger Dressel" and not "Holger Dressler".

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4.2. Multi-component intervention and neck pain-related work productivity loss

Manuscript

Please find the submitted manuscript entitled “A multi-component intervention (NEXpro) reduces neck pain-related work productivity loss: A randomized controlled trial among Swiss office workers” on the next pages.

Contribution

AMA took the lead in preparing the manuscript and in communicating with the authors and the journal. For further information on the contribution of all authors, see the corresponding chapter of the manuscript. The following sections describe additional work related to this manuscript. Office workers within the two organizations were recruited by AMA and MD. Screening for eligibility and obtaining informed consent was handled by AMA and MM. Unblinded allocation to clusters of eight office workers was performed by AMA and MD, and blinded randomization at a cluster level was done by TV. AMA, supported by MD, was responsible for the communication with the participants throughout the study period.

The intervention was conducted by AMA, MD, and with the help of four students in Bachelor and Master programs from universities in Switzerland. The questionnaire was created by AMA and MD using the online survey tool UNIPARK© and sent to participants by MD. AMA cleaned the data under supervision of MD. The statistical analysis was performed by TV in close collaboration with AMA and BB. Interpretation and discussion of the results was led by TV, AMA, and BB in consultation with MD, MM, AE, GS, VJ, JD, MJE, HL, HD, and OD.

A multi-component intervention (NEXpro) reduces neck pain-related work productivity loss: A randomized controlled trial among Swiss office workers

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1. Abstract

Purpose: Neck pain is common among office workers and leads to work productivity loss. This study aimed to investigate the effect of a multi-component intervention on neck pain-related work productivity loss among Swiss office workers.

Methods: Office workers, aged 18-65 years, and without serious neck-related health problems were recruited from two organisations for our stepped-wedge cluster randomized controlled trial. The 12-week multi-component intervention included neck exercises, health-promotion information, and workplace ergonomics. The primary outcome of neck pain-related work productivity loss was measured using the Work Productivity and Activity Impairment Questionnaire and expressed as percentages of working time. In addition, we reported the weekly monetary value of neck pain-related work productivity loss. Data was analysed on an intention-to-treat basis using a generalized linear mixed-effects model.

Results: Data from 120 participants were analysed with 517 observations. At baseline, the mean age was 43.7 years (SD 9.8 years), 71.7 % of participants were female (N = 86), about 80 % (N = 95) reported mild to moderate neck pain, and neck pain-related work productivity loss was 12 % of working time (absenteeism: 1.2 %, presenteeism: 10.8 %). We found an effect of our multi-component intervention on neck pain-related work productivity loss, with a marginal predicted mean reduction of 2.8 percentage points (b = -0.27; 95 % CI: -0.54 to -0.001, p = 0.049). Weekly saved costs were Swiss Francs 27.40 per participant.

Conclusions: Our study provides evidence for the effectiveness of a multi-component intervention to reduce neck pain-related work productivity loss with implications for employers, employees, and policy makers.

Keywords: absenteeism; ergonomics; exercise; health promotion; presenteeism

Trial registration: ClinicalTrials.gov, NCT04169646. Registered 15 November 2019 - Retrospectively registered, https://clinicaltrials.gov/ct2/show/NCT04169646

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2. Introduction

Non-specific neck pain is one of the most common musculoskeletal disorders worldwide and ranked fourth in terms of disability in the 21st century [1]. The 12-month-prevalence of neck pain ranges from 30 to 50 % [2], with recurrence rates of 50 to 75 % within the first five years of onset [3]. Especially among office workers, neck pain is one of the most frequently reported complaints: About 68 % of Swiss office workers experience at least one day per year with non-specific neck pain [4], and one in four report work productivity loss due to neck / shoulder pain [5].

Neck pain imposes an impact at the individual and societal level. At the individual level, there is reduced function and quality of life, increased pain and disability [1]. At a societal level, neck pain has health-related economic consequences [1,2]. In Switzerland, for example, the annual direct costs of neck and back pain amount to Swiss Francs (CHF) 3.8 billion, and the indirect costs, including absenteeism and presenteeism, to CHF 7.5 billion [6]. These consequences become more relevant considering neck pain has a high recurrence rate (e.g., flare-ups) and risk of persistence [1,2]. Thus, the need to minimize the burden of neck pain among office workers is of interest to many, not only the affected persons themselves, but also the employers and insurance companies.

From an employer's perspective, current literature describes various approaches to reducing neck pain-related productivity loss in the workplace. Two studies found a positive effect of workplace health promotion alone on health-related work productivity, absenteeism, and presenteeism [7,8]. Workstation ergonomics alone was shown to positively influence productivity in asymptomatic office workers [9] and absenteeism in office workers with upper limb symptoms [10], but not in office workers with neck pain [11]. Workplace-based exercise was able to reduce neck pain among office workers [12,13] with work productivity and absenteeism remaining unchanged [11,14]. Interestingly, several studies on workplace strengthening exercises concluded that exercise frequency was not related to a reduction of neck pain [15,16]. Pereira et al. [17] studied a combination of the previously mentioned intervention approaches and showed that office workers with neck pain who attended a best practice workplace ergonomics and neck exercise programme had a lower absenteeism than those who attended a workplace ergonomics and health promotion programme. In summary, the different approaches – whether applied as a single or combined intervention – provide mixed findings, mostly with small effects, on work productivity loss among symptomatic and asymptomatic office workers. However, the neck pain-related productivity improvements among office workers may be greater if available and best-evidence interventions were combined and tested against a true control group [17-19].

The aim of this trial was therefore to investigate the effect of a multi-component intervention on neck pain-related work productivity loss in office workers. We hypothesised that our multi-component intervention would reduce the economic burden of neck pain in office workers by improving neck pain-related work productivity.

3. Methods

3.1. Study design

This study was a stepped-wedge cluster randomized controlled trial with each participant completing a control and intervention period [20]. Detailed information can be found in the trial profile (Figure 1) and the study protocol [18]. Due to the COVID-19 pandemic and the consequent first lockdown in Switzerland, the timing for intervention delivering for the second cluster was delayed by 4 months to August 2020 and by 4 months for cluster 3 to January 2021. Accordingly, the study duration increased from 12 to 16 months. This approach ensured consistency in delivery mode for all participants. Approval was given by the Ethics Committee of the Canton of Zurich, Switzerland (swissethics no. 2019-01678). The CONSORT 2010 Statement extension to cluster randomised trials was used to guide the reporting of the trial [21].

3.2. Participants, recruitment, and randomization

Participants had to be office workers aged 18 to 65 years who worked more than 25 hours per week (0.6 full-time equivalent) in a predominantly sitting position, suffered from neck pain or were interested in preventing them, could communicate in German, and gave written informed consent [18]. Participants were excluded if they had a serious health problem that met the European taskforce recommendations [22]: previous trauma or injury to the neck (e.g., neck pain grade 4) [22], specific diagnosed pathology of the neck (e.g., fracture), inflammatory disease of the neck (e.g., spondyloarthropathies), or previous neck surgery [18]. Furthermore, participants who had planned an absence longer than four weeks during the intervention and pregnant women were excluded. Participants with known contraindications to performing neck exercises (e.g., on medical advice) were not allowed to participate.

Recruitment took place from October to December 2019 in two medium-sized, governmental-funded Swiss organisations in the cantons of Zurich and Aargau; one was in the higher education sector (Zurich University of Applied Sciences, School of Applied Linguistics and School of Management and Law) and the other in the service sector (Canton Aargau, Department of Civil Engineering, Transport and Environment) [18]. Employees were informed by e-mail, intranet, and during lunch meetings and those interested in participating were asked to register on a website. On a first-come, first-served basis, office workers were then contacted by phone and screened for inclusion and exclusion criteria (AA, Figure 1).

Participants who worked in the same organisation, on the same floor or in the same room were assigned to the same group (de-identified by AA) to avoid contamination, resulting in a total of 15 groups of 8 participants in each. These 15 groups were then randomly assigned to the intervention cluster (1, 2, and 3) by computer by a senior biostatistician (TV) who was blinded to the identity of the participants. All participants within a cluster changed from the control to the intervention period at the same time and according to the timing of the specific intervention cluster.

3.3. Multi-component intervention

The intervention lasted 12 weeks and consisted of a workstation ergonomics intervention, weekly group health-promotion information workshops, and neck exercises [18].

Best practice workstation ergonomics was applied individually by an expert using an assessment checklist adapted to Swiss guidelines [23]. This 30-minute intervention covered topics such as monitor, desk, and chair adjustment, and was carried out once within the first two weeks after the commencement of the intervention period. Participants were then instructed to adhere to best practice workstation ergonomics during the rest of the intervention period.

Weekly health-promotion workshops lasted 45 minutes each and consisted of information and practical activities. Group size was up to 12 participants and the content was discussed in the following order: 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. The content was selected on the basis of a previous study [17], in consultation with international experts, and the two organisations involved in this trial. Participants were recommended to attend at least 8 of the 12 workshops.

Participants were instructed to perform neck exercises at a minimum of three times a week for 20 minutes (one hour per week in total) in a group setting and in a dedicated room at the workplace. One session per week was supervised, and the remaining sessions were self-administered. All participants were given a standard set of 16 exercises targeted to the neck and upper body (Supplementary Information) [17,18]. The number and selection of exercises within the 20-minute sessions and the progression of exercise over the 12 weeks were within the participant's individual capabilities. At each training session, participants performed warm-up exercises, followed by strength and cool down exercises. The training load for strength exercises was defined at a 10-repetition maximum (10-RM), with two to three sets of 10-15 repetitions. Training intensity was re-assessed during supervised exercises sessions at regular intervals (three, six, and nine weeks), progressing from un-resisted to resisted exercises using elastic resistance bands. Between sets, breaks were taken to avoid overexertion. All participants received an app (Physitrack®, London, UK) which could be accessed via smartphone, tablet, or desktop computer. The app displayed a video of each exercise, provided a training reminder and feedback function, and allowed training to be recorded (e.g., number of training sessions).

Interventions were delivered by physiotherapists, movement scientists, and / or Master of Psychology students. All were trained for at least four hours before intervention commencement. Participants could report the time spent for interventions as working time, except for the supervised neck exercise sessions only. Office workers who had already completed the intervention period were advised by the research team to continue training on an unsupervised basis. Due to the COVID-19 pandemic, the intervention was delivered from March 2020 onwards in a hybrid format (participation on-site or via video teleconference). It was not mandatory that all participants in the same cluster received the intervention on the same day of the week, so the group size could be larger than eight.

3.4. Outcomes

The five measurement time points (baseline, follow-up 1 to 4) at four-month intervals are shown in the trial profile (Figure 1). Regardless of whether the participant was in the intervention or control period, measurements were made at the same time point for all participants. All data were obtained using online questionnaires, each taking about 30 to 45 minutes to complete, and were hosted by the tool UNIPARK© (Berlin, Germany). Participants could report the time spent for completing the questionnaires as working time.

3.4.1. Primary outcome

The primary outcome of neck pain-related work productivity loss was expressed as a percentage of weekly working time. It was quantified with the Work Productivity and Activity Impairment Questionnaire for Specific Health Problem (WPAI, German version) [24], which includes the following questions with a recall frame of one week: Q1 = currently employed; Q2 = hours missed due to neck pain; Q3 = hours missed due to other reasons (e.g., vacation); Q4 = hours actually worked; Q5 = degree to which neck pain affected work productivity (on a Numeric Rating Scale NRS ranging from 0 = not at all to 10 = maximum) [24]. Neck pain-related percentages of absenteeism (Q2/(Q2 + Q4) and presenteeism ((1-absenteeism) * Q5/10)) were calculated according to the scoring rules of the developers and summed to obtain the neck pain-related work productivity loss [24]. The monetary value of neck pain-related work productivity loss (in CHF) was calculated [24], which is described in detail in statistical analysis section.

3.4.2. Additional variables

Other information collected included: employer (Zurich, Aargau), workload percentage (< 80 %, 80 – 89 %, 90 – 99 %, 100 %), work role (with or without a leadership responsibilities), education level (tertiary level education, non-tertiary level education), average weekly earnings (in CHF), civil status (married, not married but in a relationship, not married and not in a relationship), nationality (Swiss, non-Swiss), intensity of the neck pain (Numerical Rating Scale (NRS) from 0 = no pain to 10 = maximum pain), gender (male, female), and age. Work-related stress conditions were assessed using the Job-Stress-Index (JSI). The JSI is based on validated questionnaires and represents the ratio of work-related resources (e.g., holistic work tasks) to stressors (e.g., time pressure) [25]. It ranges from 0 to 100, with a value below 45.879 representing a favourable range (resources > stressors), a sensitive range of 45.880 – 54.122 (resources = stressors), and a critical range above 54.123 (resources < stressors) [25].

3.5. Sample size calculation

For sample size calculation, a baseline work productivity of 90 % and an intervention-related work productivity increase of 5 % were assumed [17]. Type I Error was set at alpha = 0.05 and Type II Error at beta = 20 % (power = 80 %). We decided for the scenario of 12 groups with six participants each, but due to the attrition rate of nearly 20 % of a previous Australian study [17] we increased the number of groups and subjects per group by 20 % each [18,26]. Thus, we enrolled 120 participants over 15 groups for four measurement time points (480 observations). As described in the study design section, the study duration increased from 12 to 16 months due to the COVID-19 pandemic. Therefore, an additional (fifth) measurement time point was added (follow-up 4) thus increasing the number of observations to 600.

3.6. Statistical analysis

Descriptive statistics with mean, median, standard deviation, maximum, and minimum value were used to characterize participants. Where variables were nominal or ordinal (e.g., gender), relative and absolute frequencies were reported.

For the primary outcome, a generalized linear mixed-effects model of the Gaussian family with log-link was fitted to the data to estimate the change in neck pain-related work productivity loss [27]. The model included a random intercept term to account for repeated measurements on the same cohort of participants as well as fixed effects for intervention cluster (cluster 1, 2, or 3), treatment (intervention, control), and time (measurement time point; baseline, follow-up 1, follow-up 2, follow-up 3, follow-up 4) [27]. The latter provided indication of whether conditions during the COVID-19 pandemic were the same for all study participants. Due to the study design, sample size calculation and statistical analysis plan (i.e., limited degrees of freedom), no further control for a confounding effect of the COVID-19 pandemic was possible. Furthermore, the model included fixed effects for age, gender, education level, civil status, nationality, employer, workload percentage, work role, and work stress conditions (JSI) to adjust for potential confounding effects. Average marginal effects were derived from the model in order to estimate changes in work productivity. The weekly monetary value of neck pain-related work productivity loss was derived by multiplying the weekly earnings by the weekly adjusted productivity loss (based on the model presented above) for both treatment groups (intervention, control), and the costs saved were the difference thereof.

The statistical analyses were performed using Stata® Version 15.1 (StataCorp, College Station, Texas, USA) and R® (Boston, USA) statistical software. Significance level was set at alpha = 0.05. We reported all model estimates with corresponding 95 % confidence intervals (95 % CI). Data analysts were blinded to the identity and group allocation of the participants. The data were analysed on an intention-to-treat basis. The study was registered on ClinicalTrials.gov (NCT04169646, https://clinicaltrials.gov/ct2/show/NCT04169646, study completed).

4. Results

Participants were recruited between Oct 28, 2019, and Dec 20, 2019. Data from 120 participants, amounting to 517 observations with an average of 4.3 observations per participant, were included in the analysis. A total of 21 observations were missing. We experienced a total of 26 dropouts (male 9, female 17; attrition rate: 22

%; Figure 1), with 13 office workers dropping out before the start of the intervention (= 31 observations), 7 during the intervention (= 18 observations), and 6 after the intervention (= 13 observations).

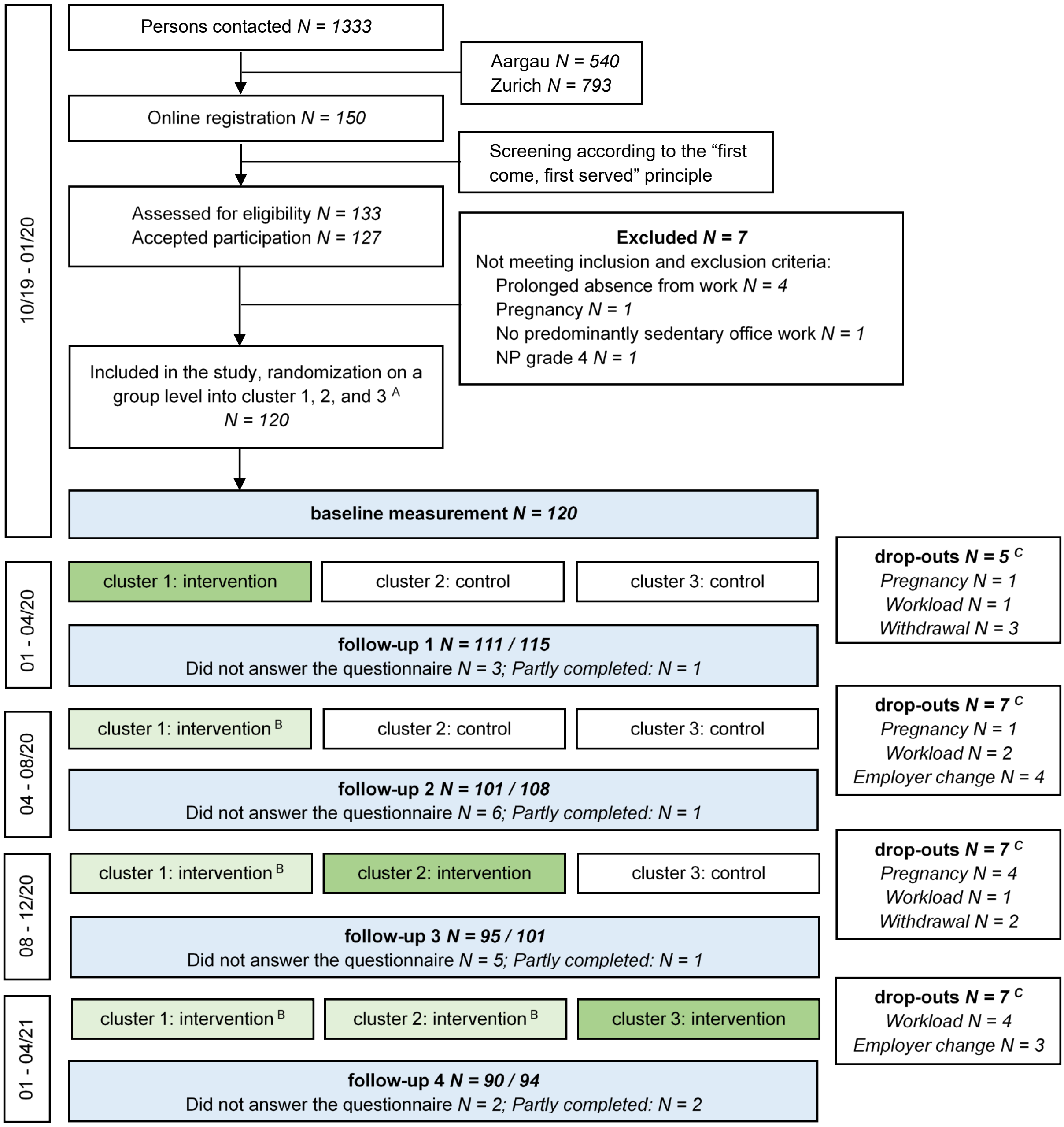
Participants' characteristics are shown in Table 1. The mean age was 43.7 years (SD 9.8 years) and the distribution by employer was balanced (Zurich: 53.3 %, N = 64). The majority of participants were female (N = 86, 71.7 %), Swiss (N = 95, 79.2 %), in a relationship (married: N = 48, 40 %; not married: N = 53, 44.2 %), and had a tertiary level education (N = 89, 74.2 %). In terms of workload, most participants worked full-time (N = 67, 55.8 %), had no leadership responsibilities (N = 76, 63.3 %), and the average monthly earnings was CHF 7679 (SD 2818). Approximately 88 % of participants (N = 106) suffered from neck pain at least at one measurement point, with 95 (79.2 %) participants reporting neck pain at baseline with a mean intensity of NRS 3.0 (SD 1.8, Median 2.0, Min 0.0, Max. 9.0, IQR 2.0). Participants with neck pain at baseline (N = 95) reported a higher neck pain-related work productivity loss (14.9 %, with 1.48 % for absenteeism and 13.5 % for presenteeism) than participants without neck pain (N = 25, 0.8 %, with 0 % for absenteeism and 0.8 % for presenteeism).

Adjusted for all confounders, the intervention was negatively associated with neck pain-related work productivity loss (b = -0.27; 95 % CI ranging from -0.54 to -0.001) yielding an average marginal treatment effect of -2.8 percentage points in the observed population. For instance, in a simplified example, an office worker working 42 hours per week would report a neck pain-related work productivity loss of 10 % (4.2 hours per week) before the intervention. After the intervention, the same office worker would report a neck-pain-related work productivity loss of 7.2 % (3 hours per week), assuming all other confounders remain constant as observed. For measurement time points, intervention clusters and the two different organisations, no association with neck pain-related work productivity loss was found (i.e., no confounding effect). With respect to the covariates, men as compared to women showed less productivity loss (-0.58; 95 % CI ranging from -1.12 to -0.03). Similarly, productivity loss was negatively associated with older age (-0.05; 95 % CI ranging from -0.08 to -0.27), and tertiary education (-0.54; 95 % CI ranging from -1.12 to -0.03). Higher productivity loss was associated with increased work stress conditions (JSI, 0.03; 95 % CI ranging from 0.005 to 0.05), not being married (in relationship: 0.79; 95 % CI ranging from 0.22 to 1.35; without partner: 0.99; 95 % CI ranging from 0.28 to 1.70), and not having leadership responsibilities (work role; 0.85; 95 % CI ranging from 0.33 to 1.37). No association was found for nationality and workload percentage with neck pain-related work productivity. The adjusted model is presented in Table 2; the unadjusted model can be found in the Supplementary Information.

The predicted monetary value of neck pain-related work productivity loss was CHF 183.90 in the control group (SD 246.70) and CHF 156.50 in the intervention group (SD 204.70) which corresponds to weekly saved costs of CHF 27.40 per participant in the intervention group.

During the control period, one adverse event occurred after a physical examination of the neck (hearing loss and tinnitus) resulting in a medical consultation. Physical examination of the neck, e.g., neck flexor strength, was a secondary outcome of this study and will be reported in a different paper [18].

Figure 1: Trial profile



Key: [A]: each cluster consists of five groups with eight participants each (N = 40), [B]: unsupervised intervention. [C]: N = 107 participants started the intervention at the allocated time point, N = 7 dropped out during the (supervised) intervention period (group 1: N = 3; group 2, N = 2; group 3, N = 2), N = 100 completed the (supervised) intervention, 94 completed the full trial (attrition rate of 22 %). Further comments: No intervention from 04 - 08/20 due to the COVID-19 pandemic. Participation rate Aargau: 10.4% (56 of 540 office workers) and Zurich 8.1 % (64 of 793 office workers).

Table 1: Participant characteristics at baseline

	Baseline (N=120)
Workload percentage	
< 80 (%)	25 (20.8 %)
80 - 89 (%)	28 (23.3 %)
90 – 99 (%)	19 (15.8 %)
100 (%)	48 (40.0 %)
Job-Stress-Index [0-100]	
Mean (SD)	47.6 (5.0)
Median (IQR)	46.8 (6.2)
Job-Stress-Index [categories]	
favourable range (JSI below 45.879; resources > stressors; %)	50 (41.7)
sensitive range (JSI between 45.880 and 54.122; resources = stressors, %)	54 (45.0)
critical range (JSI above 54.123; resources < stressors; %)	16 (13.3)
Neck pain-related work productivity loss [% of working time]	
Mean (SD)	12.0 (19.4)
Median (IQR)	0 (12.5)
Neck pain-related presenteeism at work [% of working time]	
Mean (SD)	10.8 (16.9)
Median (IQR)	0 (10.0)
Neck pain-related absenteeism at work [% of working time]	
Mean (SD)	1.2 (9.2)
Median (IQR)	0 (0)

Key: IQR = interquartile range; SD = standard deviation

Table 2: Neck pain-related work productivity loss (%), adjusted model with 517 observations

	Coefficient	95 % confidence interval	p-value
Treatment, intervention (Ref = control)	-0.27	from -0.54 to -0.001	0.049
Measurement time point (Ref = Baseline, January 2020)			
Follow-up 1 (April 2020)	-0.01	from -0.26 to 0.23	0.93
Follow-up 2 (August 2020)	0.17	from -0.05 to 0.40	0.13
Follow-up 3 (November 2020)	0.02	from -0.26 to 0.31	0.86
Follow-up 4 (April 2021)	0.16	from -0.20 to 0.52	0.38
Intervention cluster (Ref = Cluster 3, January to April 2021)			
Cluster 1 (January to April 2020)	-0.54	from -1.08 to 0.01	0.053
Cluster 2 (August to November 2020)	-0.39	from -0.90 to 0.12	0.14
Age	-0.05	from -0.08 to -0.03	< 0.001
Gender, male (Ref = female)	-0.58	from -1.12 to -0.03	0.04
Education, tertiary (Ref = non-tertiary level)	-0.54	from -1.12 to 0.03	0.07
Civil Status (Ref = married)			
not married, in a relationship	0.79	from 0.22 to 1.35	0.01
not married, not in a relationship	0.99	from 0.28 to 1.70	0.01
Nationality, Non-Swiss (Ref = Swiss)	0.37	from -0.13 to 0.88	0.15
Employer, Aargau (Ref = Zurich)	0.03	from -0.50 to 0.55	0.93
Workload percentage (Ref = 100 %)			
90-99%	-0.37	from -1.03 to 0.29	0.28
80-89%	-0.15	from -0.71 to 0.41	0.59
< 80%	0.49	from -0.15 to 1.13	0.13
Work role, with leadership responsibilities (Ref: without leadership responsibilities)	0.85	from 0.33 to 1.37	0.001
Job-Stress-Index	0.03	from 0.005 to 0.05	0.02
Model Constant	1.71	from 0.88 to 2.54	< 0.001
Random Intercept Variance (participants)	0.69	from 0.44 to 1.10	
Residual Variance	150.52	from 132.06 to 171.55	

5. Discussion

5.1. Summary of findings

About 80 % of our sample of Swiss office workers reported mild to moderate neck pain (average NRS 3.0/10) at baseline and neck pain-related work productivity loss was 12 % of working time at baseline (combination of absenteeism and presenteeism). We found an effect of our multi-component intervention on neck pain-related work productivity by -2.8 percentage points and weekly saved costs of CHF 27.43 per participant. In addition, a negative effect for the covariates of male gender, older age, and tertiary education level on the loss of work productivity was found. Increased work stress conditions (JSI), not being married, and not having leadership responsibilities were positively associated with neck pain-related work productivity loss. Our hypothesis that the intervention could reduce the economic burden of neck pain in office workers was confirmed by these findings.

5.2. Interpretation and comparison with literature

Overall, our findings are consistent with existing literature. Justesen et al. [28] investigated the effect of a 12-month individual physical exercise programme combined with moderate-intensity activity and found evidence for a reduction in absenteeism, presenteeism, and productivity loss at work, but only for office workers with high adherence to the intervention. Pereira et al. [17] compared two 12-week intervention programmes, with participants who attended a workplace ergonomics intervention and neck exercise programme showing a lower health-related work productivity loss at 12-month follow-up than those who attended a workplace ergonomics and health promotion programme. Their monthly saved health-related work productivity costs amounted to 186 CHF ($ 276) at 1-year follow-up [17]. This value is very similar to the value of saved costs from our study of about 27.50 CHF per participant per week, considering that we only recorded the productivity losses at work due to neck pain. With regard to the covariates, the loss of neck pain-related work productivity was found to be lower in older participants, which could be explained by the more consolidated personality traits, better stress coping strategies, overall greater (work) experience, and healthy worker effect. This proposition is supported by our findings, showing that office workers who are exposed to increased work-related stressors [29,30], who have leadership responsibilities, or who are not being married also tend to have higher productivity losses at work. In addition, our findings confirm that the work productivity loss due to neck pain is significantly higher in women than in men [31].

In line with previous studies, we have found only small treatment effects of our multicomponent intervention [17,28]. Nevertheless, there are several things to consider when interpreting our values. Firstly, we expected a relatively high treatment effect, i.e. a reduction in the observed work productivity losses by 5 percentage points (reduction from 10 % productivity loss to 5 %; in relative terms: 50 %) [17]. Our observed (predicted) treatment effect of -2.8 percentage points was lower than the expected value, though still equivalent to a relative reduction of 23.5 % in work productivity losses due to neck pain compared to the baseline productivity losses of 12 %. With regard to the sample size calculation, this discrepancy between the expected and observed treatment effect reduces the power of our findings. Secondly, the burden of neck pain was comparatively low in our sample [32]: 80 % of participants reported mild to moderate neck pain and 20 % had no neck pain at baseline, which may indicate a floor effect and may have diluted the observed treatment effect. Possible reasons include the time between recruitment and baseline measurement of several weeks. This in combination with an intermittent occurrence of neck pain and a recall period of four weeks may have resulted in fewer recordings of neck pain. A regression to the mean, in contrast, was controlled by using multiple measurement time points. To summarise the first and second statement: Our intended goal of a relative reduction of 50 % in neck pain-related work productivity loss seems quite ambitious in a sample with low levels of neck pain. Nevertheless, we were able to demonstrate a statistically significant, albeit small, treatment effect of our multicomponent intervention. Thirdly, a small treatment effect in a study may still imply a larger effect at the population or worker level due to a shift in the population curve. Fourthly, there is a risk of overtreatment due to our study design. All individuals received the same intervention, regardless of their level of pain, and there was no individual matching to the intervention, making the intervention time-consuming to deliver and participate in. This should not be underestimated, especially when considering a similarly high treatment effect as in other studies, but a comparatively larger time investment for the participants. Fifthly, our sample was representative of office workers in terms of age [33], but not in terms of education level [34]. Current literature shows a negative association between work productivity losses and educational level [35], potentially due to better health literacy. However, since we measured the productivity loss as a percentage, it is unclear whether and what impact the different education levels had on the treatment effect. And sixthly, it should not be neglected that our study started shortly before the COVID-19 pandemic restrictions became effective in Switzerland. There was a national requirement to work from home during our 16-month study period (recommendation: 58 weeks, requirement: 23 weeks), which changed not only the work environment, but also to some extent the working hours, work tasks, and private commitments. As shown in the study profile, it was therefore decided not to move any cluster into the intervention period in April 2020. At that point, it was assumed that the COVID 19 pandemic would end in August 2020, and if not, this would provide sufficient time to prepare for the switch to the hybrid setting. This short-term interruption of the study thus affected all participants equally, regardless of whether they were in the intervention or the control period. The main consequence for the participants was the fact that an additional measurement point had to be added (follow-up 4). Still, one could argue the COVID-19 pandemic may have had an impact on our results in terms of dose-response (e.g., time of sedentary desk work, intensity of exercises) and attrition rate, which are both described as highly relevant predictors on treatment outcomes [36]. For example, half of the dropouts had already discontinued participation before the start of their intervention period (N = 13). However, the fact that the measurement time point was not statistically significant is an indicator that all participants had the same conditions during the study (i.e., no substantial change, [37]). Nevertheless, it remains unclear to what extent the results can be transferred to everyday office life without COVID-19.

5.3. Strengths

This study has several strengths. First, we included employees with and without neck pain, which is why our results are representative for the treatment and prevention of neck pain-related work productivity losses in office workers in general. In this way, the fluctuating nature of neck pain in office workers can be addressed more appropriately. Second, the study design minimized contamination between groups, but still allowed all participants to receive the intervention. Third, the primary outcome allowed differentiation between neck pain-related absenteeism and presenteeism at work, and not only sick leave and productivity as in previous studies [11,36]. Fourth, current recommendations for the successful implementation of such a programme were applied: medium to large companies were recruited, the intervention was carried out in the workplace and during working hours, it included training programmes and information material, and was supervised [38,39]. Fifth, the components of the intervention were selected according to the current best available evidence, which was intended to reduce neck pain and work productivity losses in office workers. Sixth, the intervention could be continued in a hybrid setting despite the COVID-19 pandemic. And finally, the intervention could be implemented or replicated with little effort as all content is available digitally: the exercises as videos on an app, the workshops as podcasts, and the workplace ergonomics in the form of a checklist.

5.4. Limitations

The high level of education, average earnings, employment by a local government, and gender distribution may have affected the transferability and comparability of our findings to other jurisdictions and samples of office workers. There may have been a selection bias as only those who had sufficient resources (e.g., time) and with mild to moderate burden of disease registered for the study participation. For our primary outcome, self-reported questionnaires were used, which are controversial because of their accuracy and potential social desirability bias. Some follow-up measurements were conducted close to holidays, so participants may not have reported neck pain or productivity losses due to vacation. Furthermore, making up for missed work hours (e.g., working overtime in another week) was not considered in the questionnaire of the primary outcome, which could lead to an overestimation of neck pain-related work productivity losses. Another limitation is the COVID-19 pandemic with the change in working conditions and the switch to a hybrid setting of our intervention, which might have biased the adherence to the intervention and the dose-response relationship, e.g., for deskwork or neck exercises. This, in turn, could lead to an underestimation of the treatment effect.

5.5. Further research

Based on our results, a cost-benefit and cost-utility analysis should be conducted to obtain a better understanding of the true health economic impact of our multi-component intervention. In addition, the effect of the COVID-19 pandemic (e.g., working from home versus working at the office, [37]) and the season (e.g., flu season in January versus August) on neck pain-related work productivity loss should be investigated using longitudinal data [40]. Future studies should compare different intervention durations (i.e., dose-response, e.g., eight and 12 weeks), control for the intake of pain relief medication and physical activity level, allow the selection of health promotion workshop content at a participant level according to their needs, investigate the sustainability of the effect (e.g., need for boosters), and include office workers with at minimum mild neck pain.

6. Conclusion

As neck pain has an impact on the individual and society and the nature of work is increasingly moving towards prolonged computer work, the burden and treatment of neck pain becomes more important. Our findings provide evidence on strategies employers and policy makers can use to improve health-related productivity by reducing absenteeism and presenteeism among office workers.

7. Statements and Declarations

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7.2. Competing Interests

The authors have no competing interests to declare that are relevant to the content of this article.

7.3. Author Contributions

Andrea Martina Aegerter recruited the organisations and participants, delivered the intervention, collected, accessed, and verified the data, performed the statistical analysis, and wrote the manuscript. Manja Deforth recruited the organisations and participants, delivered the intervention, and collected, accessed, and verified the data. Thomas Volken designed the study, wrote the funding application, and performed the randomisation and statistical analysis. Venerina Johnston designed the study, proofread the manuscript, and discussed the implementation of the study as well as interim results and COVID-19-pandemic-related changes. Hannu Luomajoki, Holger Dressel, and Oliver Distler discussed the design and implementation of the study as well as results and COVID-19-pandemic-related changes. Julia Dratva designed the study and wrote the funding application. Markus Josef Ernst collected the data and discussed the design and implementation of the study as well as interim results and COVID-19-pandemic-related changes. Beatrice Brunner designed the study and discussed the implementation of the study as well as interim results and COVID-19-pandemic-related changes. Gisela Sjøgaard designed the study and discussed the implementation of the study as well as interim results and COVID-19-pandemic-related changes. Markus Melloh designed the study, wrote the funding application, and discussed the implementation of the study as well as interim results and COVID-19-pandemic-related changes. Achim Elfering designed the study, wrote the funding application, and discussed the implementation of the study as well as interim results and COVID-19-pandemic-related changes. All authors had full access to all the data in the study, critically reviewed and revised the manuscript, approved the final manuscript, and had final responsibility for the decision to submit for publication.

7.4. Data Availability

The data that support the findings of this study are available from the corresponding author upon request.

7.5. Ethics Approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of the Canton of Zurich, Switzerland (15.10.2019, swissethics no. 2019-01678).

7.6. Consent to participate

Written informed consent was obtained from all individual participants included in the study.

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9. Supplementary Information

Article title: A multi-component intervention (NEXpro) reduces neck pain-related work productivity loss: A randomized controlled trial among Swiss office workers

Journal name: Journal of Occupational Rehabilitation

Author names: Aegerter AM, Deforth M, Volken T, Johnston V, Luomajoki H, Dressel H, Dratva J, Ernst MJ, Distler O, Brunner B, Sjøgaard G, Melloh M and Elfering A on behalf of the NEXpro collaboration group

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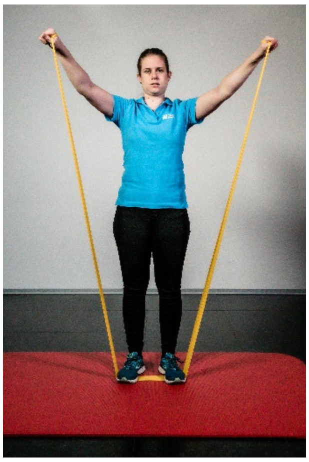
Table 3: Neck pain-related work productivity loss (%), unadjusted model with 517 observations

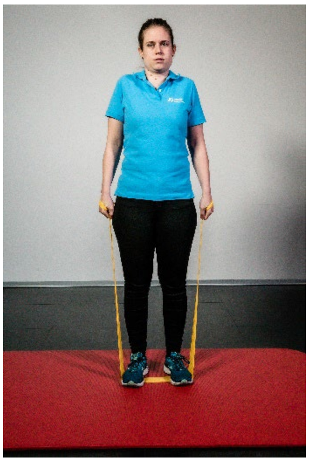
	Coefficient	95 % confidence interval	p-value
Treatment, intervention (Ref = control)	-0.19	from -0.45 to 0.07	0.16
Measurement time point (Ref = Baseline, January 2020)			
Follow-up 1 (April 2020)	-0.08	from -0.32 to 0.17	0.54
Follow-up 2 (August 2020)	-0.08	from -0.14 to 0.30	0.49
Follow-up 3 (November 2020)	-0.08	from -0.35 to 0.20	0.60
Follow-up 4 (April 2021)	-0.001	from -0.36 to 0.36	0.99
Intervention cluster (Ref = Cluster 3, January to April 2021)			
Cluster 1 (January to April 2020)	-0.55	from -1.15 to 0.04	0.07
Cluster 2 (August to November 2020)	-0.20	from -0.73 to 0.34	0.47
Model Constant	2.00	from 1.54 to 2.47	< 0.001
Random Intercept Variance (participants)	1.20	from 0.78 to 1.84	
Residual Variance	151.65	from 132.85 to 173.11	

Figure 2: Set of 16 neck exercises

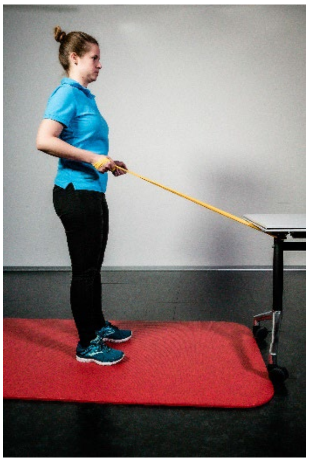
Bilateral scapular raise
3x10 repetitions



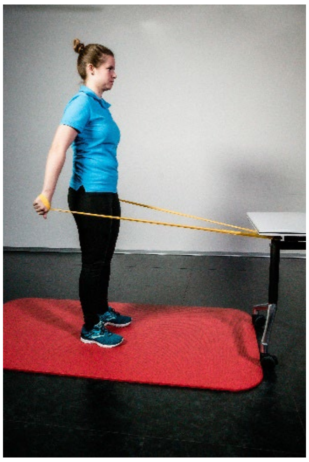
Bilateral shoulder shrugs
3x10 repetitions



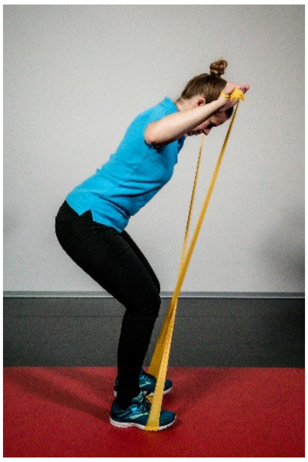
Row
3x10 repetitions



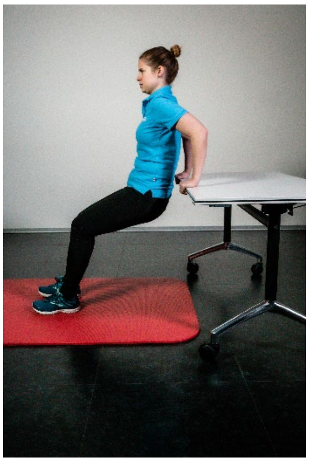
Bilateral shoulder extension
3x10 repetitions



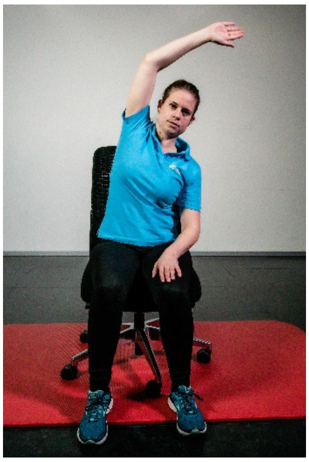
Bilateral shoulder external rotation
3x10 repetitions



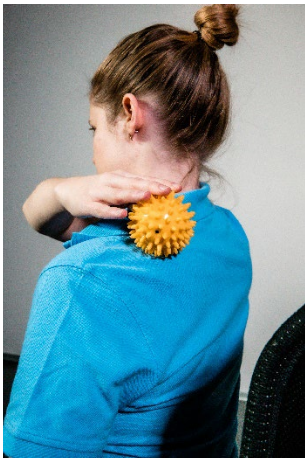
Bench dips
3x10 repetitions



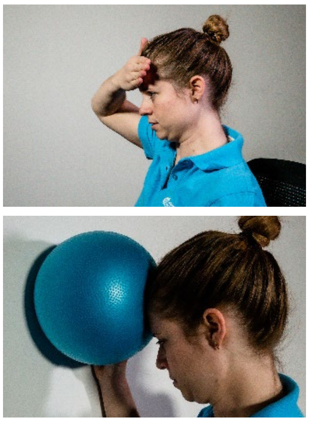
Seated side stretch
3x20 seconds, each side



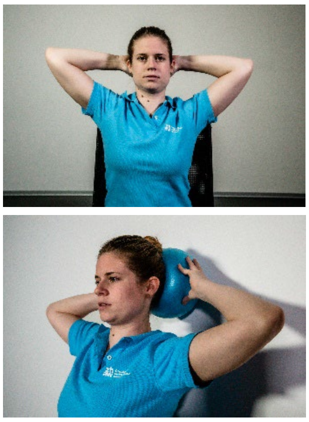
Self-massage
3x20 seconds



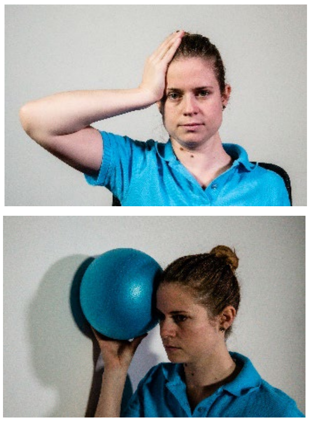
Isometric neck flexion
5x5 seconds



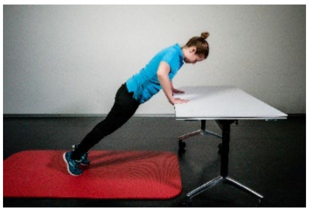
Isometric neck extension
5x5 seconds



Isometric neck rotation
5x5 seconds, each side



Push-ups
3x10 repetitions



Bilateral shoulder circling
1x20 seconds

Upper body rotation
1x20 seconds, each side

Stretch of neck extensor
3x20 seconds

Lateral neck stretch
3x20 seconds, each side

4.3. Neck pain and working from home

Publication

The publication entitled "No evidence for an effect of working from home on neck pain and neck disability among Swiss office workers: Short-term impact of COVID-19" [88] is presented on the next pages.

Contribution

AMA and MD contributed equally to this publication. AMA handled the communication with the authors and the journal. See the corresponding chapter of the publication for more detailed information. The next section describes additional work related to this publication. The idea for this research question was developed by MM, AE, AMA, and MD. AMA took the lead in writing the manuscript and MD in the statistical analysis, with both supporting each other. TV supervised the statistical analysis. The interpretation and discussion of the findings was led by AMA, MD, AE, and MM in consultation with TV, GS, VJ, JD, HL, HD, and OD.

Licence

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ORIGINAL ARTICLE

No evidence for an effect of working from home on neck pain and neck disability among Swiss office workers: Short-term impact of COVID-19

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Abstract

Purpose The aim of this study was to investigate the effect of working from home on neck pain (NP) among office workers during the COVID-19 pandemic.

Methods Participants from two Swiss organisations, aged 18–65 years and working from home during the lockdown ($n=69$) were included. Baseline data collected in January 2020 before the lockdown (office work) were compared with follow-up data in April 2020 during lockdown (working from home). The primary outcome of NP was assessed with a measure of intensity and disability. Secondary outcomes were quality of workstation ergonomics, number of work breaks, and time spent working at the computer. Two linear mixed effects models were fitted to the data to estimate the change in NP.

Results No clinically relevant change in the average NP intensity and neck disability was found between measurement time points. Each working hour at the computer increased NP intensity by 0.36 points (95% CI: 0.09 to 0.62) indicating strong evidence. No such effect was found for neck disability. Each work break taken reduced neck disability by 2.30 points (95% CI: −4.18 to −0.42, evidence). No such effect was found for NP intensity. There is very strong evidence that workstation ergonomics was poorer at home.

Conclusion The number of work breaks and hours spent at the computer seem to have a greater effect on NP than the place of work (office, at home), measurement time point (before COVID-19, during lockdown) or the workstation ergonomics. Further research should investigate the effect of social and psychological factors.

Trial registration ClinicalTrials.gov, NCT04169646. Registered 15 November 2019—Retrospectively registered, https://clinicaltrials.gov/ct2/show/NCT04169646.

Keywords Neck pain · Neck disability · COVID-19 · Pandemic · Working from home

Abbreviations

COVID-19	Coronavirus disease 2019
NDI	Neck disability index
NP	Neck pain
NRS	Numeric rating scale
RCT	Randomized-controlled trial

Background

The COVID-19 pandemic has suddenly forced around 50% of employees in Switzerland into a working from home setting during March and April 2020 [1]. In 2019, by comparison, only 24.6% of employees worked from home at least once a month and only a fraction (3%) worked predominantly from home [2]. Initial studies claimed that working from home during the COVID-19 pandemic was often performed at poorly designed workstations (49% out of 1100 respondents [3, 4]). Moreover, evidence indicates that regular break schedules were reduced such that office workers were taking fewer breaks during their work than before the lockdown (34% agreement [3]). In terms of workload, office workers experienced either under- or overwork, depending

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on their tasks and responsibilities [5, 6]. There are emerging reports that approximately one out of three office workers are more regularly performing overtime at home than previously in their offices before the lockdown [3, 4, 6].

COVID-19-related working from home appears to have changed the work experiences of office workers considerably. Positive changes (e.g., better work life balance, lower commuting demands) accompany the negative ones (e.g., loss of social contact with colleagues and supervisors, interruptions [1, 3, 6, 7]). Among the negative consequences related to working from home in times of the COVID-19 pandemic, an increase in non-specific neck pain (NP) has been reported [8, 9]. These findings need to be confirmed with higher levels of evidence, which is driver for this paper.

NP is a global burden of disease [10, 11]. In the workforce, especially among office workers, NP is epidemic [12]. Risk for NP and resources to reduce risk among office workers are multifactorial, including ergonomic, physical, psychological and psychosocial [13]. Among work-related risk factors, poor ergonomics (i.e., keyboard position close to the body, poor computer workstation design and work posture, sedentary work behaviours), high job stress, and low satisfaction with the workplace environment have been identified as risk factors in recent reviews and a longitudinal study [13–15]. Recently, some evidence for long working hours and prolonged sitting as risk factors for occupational NP has been reported [14, 16]. While long breaks during work do not seem to lower the risk of NP, evidence for frequent short breaks is weak to moderate [17, 18].

The aim of this study was to investigate the effect of the forced working from home situation during the COVID-19 pandemic on NP. We hypothesized that COVID-19-related working from home would increase NP as measured by NP intensity and neck disability. Secondly, we hypothesized that poor workstation ergonomics, the number of breaks at work, and long working hours at a computer would be associated with higher NP intensity and neck disability.

Methods

Design and participants

This is a longitudinal study based on data from an ongoing stepped-wedge cluster randomized controlled trial (RCT) [19]. The study was approved by the Ethical Commission of the Canton of Zurich, Switzerland (Swissethics No. 2019-01678). Participants were recruited from two Swiss organisations in the Cantons of Zurich and Aargau between October and December 2019. Inclusion criteria were Swiss office workers aged 18–65 years, working more than 25 h per week (0.6 full-time equivalent) in predominantly sedentary office work, able to communicate in German (written, spoken), and provided written informed consent. Exclusion criteria were severe health conditions such as previous trauma or injuries of the neck, inflammatory disease, any history of cervical spine surgery or if exercise was contraindicated [19]. For this analysis, only those participants in the control cohort (control cluster, similar to a waiting list) between January and April 2020 ($n=80$) who answered the COVID-19-related questions in full ($n=72$ out of 80) and were working from home at the time of follow-up ($n=69$ out of 72) were included (Fig. 1).

Outcomes and measures

The association of working from home with NP was analysed. The primary outcome of NP was assessed with a measure of intensity (severity) and the level of disability. The mean intensity of NP over the last four weeks was rated on a numeric rating scale (NRS) scored from 0 (no pain) to 10 (maximum pain), and the neck disability, measured with the neck disability index (NDI) scored from 0 (no disability) to 100 (high disability). Both the NRS and NDI are validated assessment instruments for use in NP populations [20, 21]. Clinically relevant results were accepted with a minimal difference of 2.5 points on the NRS or 7 points in the NDI score [22, 23]. Secondary outcomes were number of breaks during work, time spent working at the computer (hours per day without lunch break), and self-rated quality of workstation ergonomics (overall rating, e.g. height of chair and table). Workstation ergonomics was rated by the study participants using a NRS scored from 1 (very good ergonomics) to 5 (very poor ergonomics). Furthermore, the participant characteristics, e.g. educational status, were collected.

Procedure

Baseline data refers to work in the office, whereas follow-up data refers to working from home. Baseline data were collected with a 30-min online questionnaire administered in January 2020 ten weeks before the COVID-19 pandemic restrictions became effective in Switzerland, follow-up data in April 2020 during the fourth and fifth week of lockdown. On completion of the 30-min follow-up questionnaire of the main study in April 2020 (e.g., NDI, NP intensity, participant characteristics; see Aegerter et al. [19]), participants were invited to voluntarily answer another 20 COVID-19 related questions (5 to 10 min, e.g. working from home, workstation ergonomics at home and at the office). Information on workstation ergonomics in the office (i.e. at baseline before the pandemic) was collected retrospectively at follow-up. UNIPARK© (Berlin, Germany) was the platform used to host the online questionnaire.

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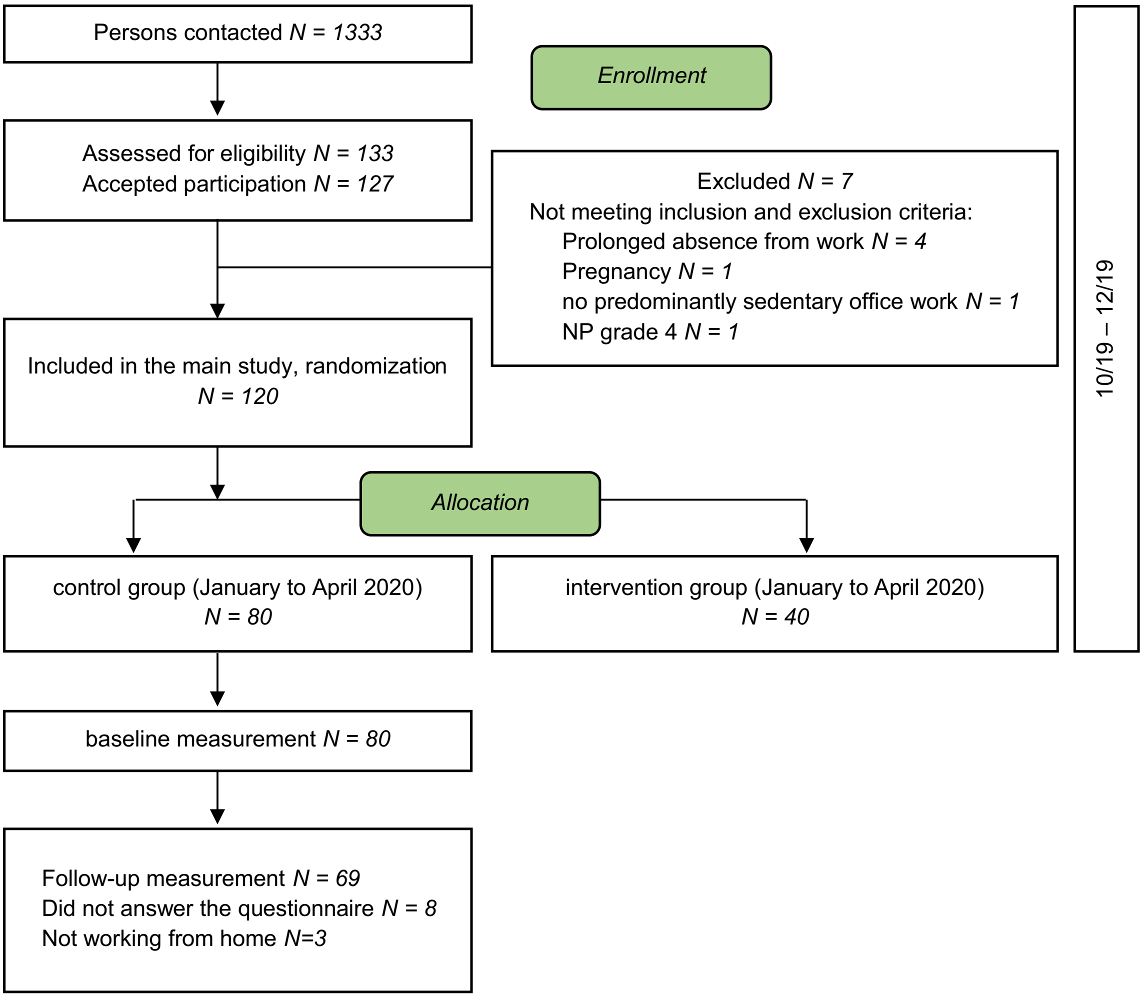

Fig. 1 Flow-chart

Statistical analysis

Participant characteristics at baseline and follow-up were analysed using descriptive statistics with mean values (including standard deviation), median, minimum, and maximum value, or in case of factor variables, relative and absolute frequencies. Wilcoxon Mann–Whitney rank sum tests were performed to investigate differences in participant characteristics between baseline and follow-up, as the assumption of normal distribution was not met.

Linear mixed effects models for repeated measures consider that measurements within a subject (participant) or time (baseline vs. follow-up) may be correlated. The strength of the evidence (confidence interval, p-value) might indicate that COVID-19-related working from home would increase or decrease NP as measured by NP intensity and neck disability. Two linear mixed effects models were fitted to the data to estimate the change in NP. The intensity of NP was the criterion variable in the first model, whereas NDI score was the criterion variable in the second model [Eqs. (1) and (2)]. The fixed effects were the same for both models: workstation ergonomics, working hours at the computer, number of breaks during work, and time. Time was included in the model to estimate whether the different measurement time points (baseline, follow-up) may have an effect on the criterion variables. An assumed normally distributed between-subject variation with zero mean and a variance for the subject's σ^2_{ID}, with ID as subject identification, was included as a random effect. Furthermore, the model contained an assumed normally distributed within-subject variation with zero mean and a variance σ^2 as an error term. Normality assumptions of between-subject and within-subject variation were verified graphically with quantile–quantile plots of random intercepts and residuals.

A sensitivity analysis extending the Eqs. (1) and (2) with the variables age and gender was performed for each linear mixed effect model. No interaction effects were integrated into the model. All analyses were performed in R using base and following analysis-specific packages: lme4 and multcomp [24]. Significance level alpha was set at 0.05. The p-values are expressed as the strength of evidence with little or no evidence ($p > 0.1$), weak evidence ($0.05 < p \leq 0.1$), evidence ($0.01 < p \leq 0.05$), strong evidence ($0.001 < p \leq 0.01$) and very strong evidence ($p \leq 0.001$) [25]. The data analyst was blinded to the identity of the participants.

The STROBE Statement checklist was used to guide the reporting of the study [26].

$$\begin{aligned} \mathrm{NPintensity}_{ij} = {} & \beta_0 + \beta_1 \times \mathrm{workstationergonomics}_{ij} \\ & + \beta_2 \times \mathrm{computerworkhours}_{ij} + \beta_3 \times \mathrm{workbreaks}_{ij} \\ & + \beta_4 \times \mathrm{measurementtimepoint}_{ij} + \mathrm{ID}_i + \varepsilon_{ij}, \text{ with } i \\ = {} & 1, \ldots, 69 \text{ subjects and } j = 1\,(\text{baseline}),\ 2\,(\text{follow - up}) \end{aligned} \tag{1}$$

$$\begin{aligned} \mathrm{NDI}_{ij} = {} & \beta_0 + \beta_1 \times \mathrm{workstationergonomics}_{ij} + \beta_2 \times \mathrm{computerworkhours}_{ij} \\ & + \beta_3 \times \mathrm{workbreaks}_{ij} + \beta_4 \times \mathit{measurementtimepoint}_{ij} \\ & + \mathrm{ID}_i + \varepsilon_{ij}, \text{ with } i \\ = {} & 1, \ldots, 69 \text{ subjects and } j = 1\,(\text{baseline}),\ 2\,(\text{follow - up}) \end{aligned} \tag{2}$$

Table 1 Participant characteristics at baseline (work in the office) and follow-up (work at home)

	Baseline ($N = 69$)	Follow-up ($N = 69$)
Neck disability index [NDI]		
Mean (SD)	11.71 (10.14)	11.10 (10.80)
Median (Min, Max)	12.00 [0.00, 52.00]	12.00 (0.00, 52.00)
Neck Pain (NP) intensity [NRS]		
Mean (SD)	2.26 (1.86)	2.14 (2.19)
Median (Min, Max)	2.00 [	2.00 [
Work breaks [number per day]		
Mean (SD)	2.38 (0.91)	2.54 (0.96)
Median (Min, Max)	2.00 [	3.00 [
Workstation ergonomics [NRS]		
Mean (SD)	1.93 (0.77)	3.35 (0.98)
Median (Min, Max)	2.00 [	3.00 [
Computer work [hours per day]		
Mean (SD)	7.46 (1.29)	7.58 (1.19)
Median (Min, Max)	7.00 [	7.00 [

Neck disability index scored from 0 (no disability) to 100 (high disability); Neck Pain (NP) intensity scored with the numeric rating scale ranging from 0 (no pain) to 10 (maximum pain) and workstation ergonomics scored on a numeric rating scale ranging from 1 (very good ergonomics) to 5 (very poor ergonomics)

Results

Data from 69 participants were analysed with 11 excluded from the analysis due to absent responses on the COVID-19-related questions ($n = 8$) or not working from home ($n = 3$, Fig. 1). The descriptive statistics of the outcomes at baseline and follow-up are shown in Table 1. About three-quarters of participants were female (71.01%, $n = 49$). Seventy-eight percent of participants had tertiary level education ($n = 54$), 20.29% ($n = 14$) completed upper secondary education and 1.45% (n = 1) primary compulsory education. The mean age was 42.20 years at baseline (SD = 9.00 years). At baseline, the average BMI was 23.53 kg/m^2 (SD = 3.47 kg/m^2), whereas it was 23.71 kg/m^2 at follow-up (SD = 3.42 kg/m^2). The average of time between completion of the questionnaires was 101.30 days (SD = 7.91 days). There was no statistical evidence for a difference in the outcomes between baseline and follow-up (Table 1), except for workstation ergonomics (p-value < 0.0001, very strong evidence).

The results of the linear mixed effects models are presented in Tables 2 and 3. NP intensity was 0.68 points lower at follow-up compared to baseline (95% CI ranging from -1.35 to 0.00, evidence), indicating a slightly lower NP intensity during the lockdown. There was strong evidence that each working hour spent at the computer increased NP intensity by 0.36 points (95% CI ranging from 0.09 to 0.62), when all other covariates remained constant. In addition, for every point higher (i.e. worse) in the quality of workstation ergonomics, the intensity of NP increased by 0.35 points (95% CI ranging from 0.02 to 0.75, evidence). There is no evidence of an association of number of work breaks with NP intensity.

Data presented in Table 3 shows that for each work break, the NDI score reduced by 2.30 points (95% CI ranging

Table 2 NP intensity

	Coefficient	95% Confidence interval	p Value
Intercept	−0.71	From −2.93 to 1.50	0.53
Workstation ergonomics	0.39	From 0.02 to 0.75	0.04
Hours of computer work	0.36	From 0.09 to 0.62	0.01
Number of work breaks	−0.18	From −0.53 to 0.18	0.33
Measurement time point (follow-up)	−0.68	From −1.35 to 0.00	0.05

Estimated coefficients of workstation ergonomics, hours of computer work, number of work breaks, and measurement time point

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Table 3 NDI

	Coefficient	95% Confidence interval	*p* Value
Intercept	16.52	From 4.96 to 28.35	0.01
Workstation ergonomics	−0.15	From −2.09 to 1.79	0.88
Hours of computer work	0.13	From −1.26 to 1.51	0.86
Number of work breaks	−2.30	From −4.18 to −0.42	0.02
Measurement time point (follow-up)	−0.05	From −3.68 to 3.59	0.98

Estimated coefficients of workstation ergonomics, hours of computer work, number of work breaks and measurement time point

from −4.18 to −0.42, evidence), when all other covariates remained constant. There was no evidence of an association of workstation ergonomics, hours of computer work or measurement time point with neck disability.

All model assumptions were met. The log-likelihood test was not significant. A sensitivity analysis showed no evidence for an effect of gender or age on the results. There was no difference in the baseline data of the participants ($n=69$) compared to those excluded ($n=11$).

Discussion

Summary of findings

Our data yielded no evidence that neck disability, number of work breaks, or number of hours of computer work changed between pre COVID-19 pandemic (working at the office) and follow-up during the lockdown (working from home). However, we found evidence of a 0.68-point reduction in NP intensity during the lockdown. The number of hours working on a computer and the quality of workplace ergonomics may have an increasing effect on NP intensity, whereas the number of daily work breaks may decrease neck disability. There is strong evidence that workstation ergonomics was poorer when working from home compared to work in the office, but no association of time point of measurement with neck disability was found.

Interpretation and comparison with literature

Overall, our findings are consistent with results previously presented in the literature [15–17]. In contrast to a recent report [9], our first hypothesis, that COVID-19-related working from home would increase NP intensity and neck disability, was not confirmed. Instead, NP intensity seemed to have decreased during the lockdown by slightly less than one point on the NRS. This could be due to the low level of NP intensity and neck disability at baseline. In our sample the prevalence of NP was very high (79%) due to the inclusion criteria, albeit low in severity (mean NRS 3.06 at baseline, NRS 2.81 at follow-up). It is more difficult to find a difference in people who are already mildly affected, as the measurement tool chosen (NRS) is not sufficiently sensitive to change [27]. Moreover, pain is multidimensional experience and is episodic, which means that not only disability and intensity (severity) but also frequency, duration, quality, localisation, and extent must be considered in NP analysis. Another possible reason for the findings could be the short follow-up time frame. Although there is evidence that a difference in NP can be observed after only a few weeks [28], the period of working from home might not have been enough long to cause a clear and clinically relevant change in NP. Therefore, it would be interesting to investigate potential long-term changes such as 12 months.

The second hypothesis, that poor workstation ergonomics, the number of breaks at work, and long working hours at a computer would be associated with higher NP intensity and neck disability was partially confirmed. Although Côté et al. [15] found no association of poor workstation ergonomics with NP intensity and neck disability, other studies have reported a negative association between the number of work breaks with NP intensity and neck disability [17], and a positive association for hours of computer work with NP intensity [16] which was confirmed in our analysis. Discrepancies in findings could be due to the method of assessing these outcomes (e.g., self-reported), the time frame and a small sample size.

Other findings of interest might be, that the number of breaks at work and the number of working hours did not increase significantly during the lockdown. This could be due to organisations as well as occupational health and safety regulators proactively managing the risk for injury by providing ideas and tips on how to stay well while working from home via various channels [29]. It is possible that the statistically significant worsening of workstation ergonomics during working from home may have been effectively counterbalanced by a decrease in risk factors or an increase of resources such as social support at work which was not measured in our study [30].

According to the biopsychosocial model of health, other factors such as biological (e.g., neck muscle endurance, physical activity level), psychological (e.g., job stress), or social (e.g., relationships) could have a greater effect on NP than the predictors analysed in this paper [31]. One possible assumption would be that most people may have experienced a decrease in work satisfaction and general well-being as well as a loss of communication and social exchange with colleagues and supervisors during the lockdown [7]. Compared to the work in an office, working from home requires greater self-regulation, work organisation (e.g., time structure), technical skills (e.g., new online tools), and a better distinction between work and private life (e.g., psychological detachment from work, work-family issues) [7, 29, 32]. As an example, it may happen that the employees notice too late that they are tired and need a work break. In addition, the duration and activity during the break might have changed while working at home, and the working time in general might have changed to be more flexible.

Another issue to consider is mental health and psychological distress, as there is evidence that people have become lonelier and more depressed while working from home [33, 34]. Compared to other samples, our study population is highly educated and was not challenged by an increase in job insecurity before, during, or after lockdown [29]. An important factor might be that the workers did not have to commute and so they had more leisure time (e.g., change in sleep duration or physical activity level, [35]). Hence, the current study may have underestimated the effects on NP during lockdown.

Limitations

All office workers were employed by the local government. There were no reduced working hours during the lockdown and the level of employment (full time vs. part time) did not change. Therefore, the results cannot be generalised to office workers in the private sector, where the COVID-19 pandemic may have led to substantial changes in work organisation and increased unemployment and job insecurity.

In this analysis, social desirability bias cannot be excluded, as all data were collected using an online questionnaire (subjectivity). The measurement time point after five weeks in lockdown may have been insufficient to change NP (dose–response). The quality of workstation ergonomics at the office was assessed retrospectively at the time of follow-up, which may have led to recall bias. Moreover, no objective criteria for assessing workstation ergonomics were provided (e.g. correct height of the table), which may have led to biased results.

Non-responder bias was potentially small with a participation rate of 86% ($n = 69$ out of 80). There are three possible explanations for this rate. Firstly, only participants who completed the additional questions after the 30-min main questionnaire were included for analysis. This method was chosen to minimise the impact on the response rate of the ongoing RCT. Secondly, it is likely that intervention studies show higher drop-out rates during COVID-19, driven, among other things, by the sociodemographic and health status of the participants. Thirdly, as the ongoing RCT is a stepped-wedge design, all participants will receive the intervention. Thus, allocation to the control group is unlikely to have affected responses to the questionnaires or the response rate (responder-bias). In addition, the baseline levels of NP did not differ between participants and those excluded. Nevertheless, the sample size in this analysis is rather small. Sample size, corresponding statistical power, and the greater than expected dropout rate in our sample may have led to decreased power in detecting a true effect in our sample.

Clinically relevance

Overall, the coefficients of the linear mixed effects models are very small. To achieve a clinically relevant change in NP intensity of at least 2.5 points, the change on the respective scale (covariate) must differ by several units; e.g. a reduction of computer work of seven hours. The effect of workstation ergonomics on NP intensity is not considered clinically relevant. A greater change would be necessary than is possible on the corresponding scale (seven points on a five-point scale). The reduction of 0.68 points on the NRS at follow-up is also not considered clinically relevant as it does not exceed the minimum detectable change of 1.5 points [36]. In contrast, three additional work breaks are required for a clinically relevant change in neck disability (7 points).

Implications

In general, the number of work breaks and time spent at the computer seem to have a greater effect on NP than the place of work (at home vs. at the office), measurement time point (before the COVID-19 pandemic vs. during the lockdown), or the workstation ergonomics. It therefore seems important to inform and raise awareness on these two aspects, rather than about the acquisition of ergonomic equipment to improve NP.

Further research

Further dimensions of pain, such as frequency, duration, location, quality, or extent would need to be investigated to enable more comprehensive statements about NP. The effect of psychosocial factors, such as mental health, or aspects such as commuting should be assessed in future studies. In other study populations, job insecurity could also play a significant role. Studies with a larger sample size or a longer follow-up phase are highly recommended, both of which will be difficult, as the collection of data prior to the COVID-19 pandemic will often result in high recall bias. With regard to work breaks, the duration of these breaks as well as their type (e.g. active vs. passive work breaks) should be investigated. Further studies should also consider variables of family structure especially in view of the closures of schools and day care centres introduced during the pandemic [29].

Conclusion

COVID-19 pandemic forced many office workers to work from home. In this study, we investigated the effect of working from home on NP intensity and neck disability among office workers and found no evidence for a clinically relevant change in NP after five weeks of working from home. The place of work (at the office or at home), measurement time point (before COVID-19 vs. during the lockdown) and workstation ergonomics had no clinically relevant effect on NP, neither the intensity nor the level of disability. However, we found evidence that three additional breaks during work might reduce the degree of neck disability. NP intensity was found to be increased by the numbers of hours working on a computer, although a clinically relevant change requires large changes in work hours (at least seven). With regards to further research, the effect of psychological and social factors should be investigated in more detail, as COVID-19 has changed everyday life, not only at the workplace.

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Declarations

Conflicts of interest The authors declare that they have no competing interests. The authors state that they have full control of all primary data and that they agree to allow the journal to review their data if requested.

Consent to participate Written informed consent was obtained from study participants.

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5. Discussion

5.1. Summary

The NEXpro project was the first to develop and design a 12-week multi-component intervention and examine its effect on neck pain-related productivity losses in office workers. Although the RCT had to be adapted because of the COVID-19 pandemic, we were able to show an improvement in neck pain-related work productivity with participation in the intervention. Neck pain-related work productivity loss could be reduced from an average of 12% of working hours to 9.2% of working hours, which in other words corresponds to weekly saved costs of CHF 27.40 per person in the intervention group. Furthermore, no clinically relevant effect of the COVID-19 lockdown (i.e., working from home) on neck pain intensity or neck disability was observed. However, workstation ergonomics was reported to be worse at home than in the office. Additionally, a positive association was found between working time in front of the computer and neck pain intensity, and a negative association was found between the number of work breaks taken and neck disability.

5.2. Discussion and interpretation

Study protocol

We opted for a stepped-wedge cluster RCT because time and financial constraints would not have allowed us to offer the intervention to a larger sample at the same time [89]. The main disadvantage of this design is the risk of bias due to seasonality of the outcome of interest [89]. Two ways to solve this problem are described in the literature. The first is to account for the baseline values of the outcome of interest, and the second is to control for fixed time effects within the model [84]. We decided for the latter. As a positive side effect, this approach allowed us to test whether the COVID-19 pandemic affected the office workers, i.e., whether conditions remained identical at different measurement time points. In addition to fixed effects, random effects were included in the model to control for correlation of individuals within the same cluster [89].

The decision to include office workers with and without neck pain was based on the consideration that neck pain often occurs intermittently [2], making it difficult to determine who suffers from neck pain and who does not. This inclusion criteria was reflected in the recruitment: the study attracted considerable interest and we received more requests to participate than there were places available. This differs from previous studies which experienced problems in recruiting office workers, but also required a larger sample size than for the NEXpro trial. Nevertheless, the choice of this inclusion criteria is problematic, especially considering that existing neck pain can often be improved by interventions, whereas preventive interventions have very small effect sizes [28, 29, 31]. Although the heterogeneity of our sample may correspond to the actual population of office workers, it could lead to a bias in the results of, i.e., an over- or underestimation of the treatment effect.

Multi-component intervention and neck pain-related work productivity loss

The on-site multi-component intervention NEXpro was able to reduce neck pain-related work productivity loss among office workers by 2.8 percentage points or CHF 27.40 per week and participant in the intervention group. This is consistent with the researchers' hypothesis and previous literature, in which exercise showed an 8% increase in work productivity at 12 weeks [32]. In line with this, Justesen et al. [47] demonstrated an 4% increase in work ability after a 12-month exercise intervention, and Ting et al. [61] found a slight improvement in work ability at 12 weeks and 12 months for office workers with neck pain and high adherence to the intervention. In contrast to our results, a systematic review and meta-analysis concluded that workplace interventions could not improve work ability [48]. Pereira et al. [60] even reported an increase in work productivity loss after their intervention, which was about 275 Australian Dollar (AUD) at 12 weeks and AUD 300 at 12 months compared to baseline.

Several factors need to be considered when comparing and interpreting the results and assessing their relevance. First, our assumption that an intervention consisting of multiple components could lead to a higher effect size (i.e., addition or multiplication of the individual components' effect sizes) seems to have limited accuracy. Second, it should be noted that it was impossible to determine which component of the intervention had the greatest effect on work productivity as the study was never designed for that purpose [54]. The “all-or-nothing principle” (or “kitchen sink” approach) was applied, so study participation was very time-consuming and overtreatment may have occurred. Third, and consistent with the previous statement, it was not intended to measure adherence to the intervention during the control period or to provide information on long-term effects [54]. Accordingly, it is not possible to conclude about the dose-response relationship of the intervention without violating the original study design [89]. Fourth, adaptations had to be made in the design and implementation of the intervention due to regulations related to the COVID-19 pandemic. Therefore, it would be more appropriate to speak of a mixed intervention with on-site and online sessions. Fifth, it is questionable whether the intervention periods were long enough to show a full treatment effect, i.e., an improvement in work productivity. Sixth, compared to other countries, the contextual factors for workplace intervention are different in Switzerland, as employers are not obliged to offer workplace health promotion. Seventh, and surprisingly, some office workers reported that they perceived completing the survey (i.e., Job Stress Index) as an indirect intervention, which may have distorted the results of the control group.

Neck pain and working from home

Contrary to our hypothesis and existing low-level evidence [86, 87], we did not find a clinically relevant change in neck pain due to the COVID-19 pandemic (i.e., working from home compared with working in an office). An explanation might be that, although there may have been a difference in neck pain between measurement time points, we were unable to detect it in our analysis. For example, sensitivity to change was low for some instruments, or we failed to capture the appropriate dimensions of neck pain (e.g., duration, frequency). Another reason could be related to the dose-response relationship; participants had only been in lockdown for a short time with sufficient resources and compensatory mechanisms that were not included in the statistical model.

We concluded that the ergonomics of the workstation at home was worse than in the office, but without being clinically relevant to the intensity of neck pain. Furthermore, the hours spent in front of the computer and number of work breaks taken were associated with neck pain. The later indicated a dose-response relationship between neck pain and work-related factors. With that in mind, it seems important to consider the factors of work breaks, duration of computer work, and workstation ergonomics in relation and dependence to each other, rather than individually. Furthermore, we have only investigated physical ergonomics, but not the interaction of office workers with organisational or cognitive components of ergonomics [52]. Thus, it is questionable whether a physical-ergonomically optimal workstation alone is sufficient to improve neck pain or whether just as many (if not more) resources should be invested, for example, in the way work is organized.

5.3. Strengths and limitations

Sample and sample size calculation

Our participating office workers were representative of their organizations in terms of age, gender, and education level, whereas no statement on neck pain and associated work productivity loss is possible due to lack of data. Compared to the Swiss workforce, similar values to our study are found for productivity losses among workers, with an average value of 13.0% of working time in 2016, but considering all health-related losses and not only those associated with neck pain [6, 90]. The same applies to the average monthly salary of our sample of CHF 7,679 compared with the average monthly salary of the Swiss workforce of CHF 6,665 [91], which could lead to a biased result for the costs saved by participating in the intervention. In summary, our results appear to be partially representative of office workers in participating organizations, although the generalizability and transferability of our findings to other organizations, settings, countries, sectors, employment contracts, and degrees of neck pain is limited. Furthermore, it remains unclear whether only office workers with sufficient resources (e.g., time) participated, which may have led to a selection bias.

Regarding the sample size calculation, the number of participants was increased from n = 72 to n = 120 because of concerns about high dropout rates and adherence to the intervention. However, the actual dropout rate and number of missing data was much lower than expected. Therefore, an alternative approach could have been to keep individual participant adherence as high as possible rather than recruiting more office workers.

Work productivity loss

There is no gold standard for quantifying work productivity [92]. We chose the WPAI because it is validated in German and for musculoskeletal complaints and captures both health-related absenteeism and presenteeism [85]. The disadvantages of the WPAI include the quantification of presenteeism because it does not take into account for overtime worked on other days, does not allow comparison with co-workers, and does not control for the work contract (e.g., work on an hourly wage basis) [92, 93]. In addition, the recall period is seven days and workers often remember the worst day, leading to bias, especially for the highly intermittent neck pain. This is to be taken very seriously as presenteeism is the main driver in work productivity calculations and our results. In assessing absenteeism, the WPAI has been criticized for not considering the work contract and seasonality (e.g., symptoms) [93]. There is also disagreement about the definition of work productivity and who should assess it, especially for knowledge-based workers. Furthermore, different approaches are followed in quantifying work productivity, such as the friction or the human capital approach, which leads to different results. All in all, the question arises how accurately the loss of work productivity due to neck pain can be measured with instruments such as the WPAI.

In addition to our findings, it would have been beneficial to obtain information on changes in absenteeism and presenteeism, but this was not planned in our study protocol and statistical analysis plan [54]. Gender discrimination cannot be ruled out either, as more women suffer from neck pain and their salaries also appear to be lower [5, 12-16].

Neck pain

We could not control for the degree of neck pain because of the lack of degrees of freedom and the absence of an appropriate variable for this purpose. As described earlier, the low intensity of neck pain in our sample may have biased the predicted treatment effect, although this value may be closer to the actual population of office workers. In addition, a floor effect for neck pain and neck pain-related work productivity loss may have occurred because time constraints forced us to schedule all measurement time points after school vacations to maximize adherence to the intervention [54].

Mechanism of action

Our interventions, especially the health-promotion information workshops, were designed according to the Health Action Process Approach [94]. Thus, office workers were provided with knowledge about risk perception, outcome expectancy, self-efficacy, resources, barriers, action planning, coping, action control, maintenance, and recovery [73, 94]. Unfortunately, the study does not allow insights into the mechanisms of action [95], but this was not intended according to the study design [54]. It may even be that our results are attributable to the attention given to participants (i.e., Hawthorne effect) [96]. However, it would be important to gain more detailed knowledge on the processes that mediate the effects of behavior change techniques [73]. On the one hand, this would allow us to increase the efficiency of the current very time-intensive intervention, which has probably led to overtreatment. On the other hand, the effectiveness of the intervention could be further improved, for example by including additional behavior change techniques [73] such as the comparison of behavior by the addition of an exercise competition.

COVID-19 pandemic

A Swiss [97] and an Austrian [98] cross-sectional study showed that many people experienced a deterioration of their personal and professional life, quality of life, and productivity during the COVID-19 pandemic. In addition, problems with physical health [99], mental health [99], and ergonomics [100] were reported. The dose (e.g., exposure to the work environment) might thus have changed with the COVID-19 pandemic, but it is impossible to include and quantify all factors in the statistical model. Apart from that, we experienced similar problems to other RCTs conducted during the COVID-19 pandemic: reduced on-site data, missed treatments, and reduced data quality [101]. As a result, the COVID-19 pandemic may have led to a dilution effect; there may have been a change in response to treatment or a change in variance [101]. However, while being critical, it should be kept in mind that changes over time can occur even in the absence of a pandemic such as COVID-19 [101].

Blinding

Strengths included the blinding of the team, e.g., the person who performed the randomization and the statistical analysis.

5.4. Implications

The burden and treatment of neck pain is becoming increasingly important as neck pain impacts both individuals and society and the nature of work increasingly shifts toward sedentary office work. Our findings contribute to the field of research by identifying and providing evidence-based and effective strategies – i.e., a multi-component intervention – that can be used to improve health-related productivity by reducing absenteeism and presenteeism among office workers. In addition, we suggest focusing on redesigning/restructuring the physical and social work environment and on improving workers' capabilities and motivation in order to increase regular work breaks or reducing time spent on the computer rather than purchasing expensive ergonomic equipment. Both recommendations may be relevant to office workers, their workplace, health care professionals, employers, and policy makers, as they suggest effective use of available (finite) resources. Beyond that, the NEXpro project provides current Swiss data on the burden of neck pain and associated productivity losses in office workers.

5.5. Further research

A more comprehensive evaluation of the intervention would require information on cost-effectiveness, cost-benefit, and cost-utility. It would be further necessary to examine in more detail which components of work productivity, i.e., absenteeism or presenteeism, could be changed by the intervention, and whether direct costs could be reduced. In addition, there are questions about long-term sustainability and a potential seasonality of neck pain and work productivity in office workers. Next to this, it is unclear whether the results can be transferred to everyday office life without the COVID-19 pandemic. From the affected person's perspective, it would be necessary to evaluate whether the intervention was able to change neck pain, quality of life, and job satisfaction.

Future studies should investigate how interventions work, i.e., what the underlying mechanisms of workplace interventions are and whether these mechanisms can actually be changed by the intervention, which would allow the intervention to be reduced to its necessary components [94, 95]. Other intervention components (i.e., individuals' physical activity, emotion regulation, or self-regulation, as well as environmental factors such as work breaks, alternative workplaces, or standing desks) could be important in considering intervention design. Finally, it would be of interest to investigate whether the intervention can be transferred to a different setting or sample. For example, small organizations with few resources for occupational health management or a different work environment (e.g., virtual) would be conceivable.

5.6. Conclusion

Our expectation was confirmed that the heterogeneous population of office workers, the various factors contributing to the development of neck pain, and the associated loss of work productivity would be addressed through the application of a multi-component intervention. Furthermore, we concluded that the COVID-19 lockdown (i.e., place of work, workstation ergonomics) did not change neck pain, while the time spent at the computer and the number of work breaks and were associated with neck pain intensity and neck disability.

6. List of abbreviations

AE	Achim Elfering, Prof. Dr. phil.-nat.
AMA	Andrea Martina Aegerter, MSc
AUD	Australian Dollar
BB	Beatrice Brunner, Dr.
CHF	Swiss franc
CN	Corinne Nicoletti, Dr.
COVID-19	Coronavirus disease 2019
GS	Gisela Sjøgaard, Prof. em. Dr.
HD	Holger Dressel, Prof. Dr. med.
HL	Hannu Luomajoki, Prof. Dr. phil.
IE	Irene Etzer-Hofer
JD	Julia Dratva, Prof. Dr. med.
MD	Manja Deforth, MSc
MJE	Markus Josef Ernst, MSc
MM	Markus Melloh, Prof. Dr. med.
n	Number (e.g., of participants)
NEXpro	Neck exercise for productivity
OD	Oliver Distler, Prof. Dr. med.
RCT	Randomized controlled trial
TV	Thomas Volken, Prof. Dr.
VJ	Venerina Johnston, Assoc. Prof. Dr.
WPAI	Work Productivity and Activity Impairment Questionnaire (e.g., for Specific Health Problem)

7. Glossary

Absenteeism	Being absent from work, i.e., staying at home due to neck pain [82, 102]. Sometimes an even more precise distinction is made, which relates to the motivation or reason for absence. On the one hand, absenteeism is defined by the fact that the individual would be able to work but nevertheless stays away from work. On the other hand, in the case of sickness absence (or sick leave), the individual is unable to work.
Presenteeism	Being present at work but with a reduced work productivity and performance, i.e., lack of concentration due to neck pain [82, 102].
Sick leave	See absenteeism
Sickness absence	See absenteeism
Work ability	The ability of the individual to work (e.g., execute a task) [102].
Work performance	What an individual does at work [102]. It goes beyond efficiency of work and includes, e.g., soft skills.
Work productivity	The ability of the individual to generate an output (e.g., provide a service) that is expected from his/her work. It refers to work efficiency, i.e., relation of input (quality, quantity) and output [102].

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10. Curriculum Vitae

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Education

2019 – 2022	PhD program in Care & Rehabilitation Sciences, University of Zurich, Switzerland
2019 – 2022	Graduate Campus Student, Swiss School of Public Health, Switzerland
2018 – 2019	"Passerelle" for the PhD program in Care & Rehabilitation Sciences, University of Zurich and ETH Zurich, Switzerland
2015 – 2018	Master of Science in Physiotherapy, Zurich University of Applied Sciences, Winterthur, Switzerland. Degree: Master of Science ZFH in Physiotherapy, 31.07.2018
2010 – 2015	Bachelor of Science in Physiotherapy, Zurich University of Applied Sciences, Winterthur, Switzerland. Degree: Bachelor of Science ZFH in Physiotherapy, 31.01.2015
2006 – 2010	Gymnasium Neufeld, Bern, Switzerland. Major: Philosophy, Psychology and Pedagogy (PPP)
2002 – 2006	Secondary School, Schulen Meikirch, Switzerland
1998 – 2002	Primary School, Schulen Meikirch, Switzerland

Employment

Since 2019	PhD student and research assistant, Zurich University of Applied Sciences, School of Health Sciences, Winterthur, Switzerland
Since 2019	Physiotherapist, Medbase Win4, Winterthur, Switzerland
Since 2016	Physiotherapist, Swiss Handball Association, Switzerland
2016 – 2019	Physiotherapist, University Hospital of Zurich, Switzerland
2015 – 2016	Physiotherapist, Sportclinic Sihlcity, Zurich, Switzerland
2015	Physiotherapist, University Hospital of Zurich, Switzerland

Other

2020 – 2022	Delegate of Junior Scientists in the Faculty of Medicine (Faculty Assembly), University of Zurich, Switzerland
2020 – 2022	Delegate of Junior Scientists in University Committees and Commissions (Senate), representing the Faculty of Medicine, University of Zurich, Switzerland
2020 – 2022	PhD Representative of the PhD program in Care & Rehabilitation Sciences, University of Zurich, Switzerland