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The impact of workplace ergonomics and neck-specific exercise versus ergonomics and health promotion interventions on office worker productivity: A cluster-randomized trial

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A 12-week workplace combined ergonomics and neck-specific exercise intervention improves sickness presenteeism and monetized health-related productivity loss among a general population of office workers and longer-term sickness absenteeism for those with neck pain, when compared to ergonomics and health promotion education combined. This study provides employers of office workers sought-after evidence of health-related productivity benefit from such workplace interventions.

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Key terms: absenteeism; cluster-randomized trial; efficiency; ergonomics; health promotion; health promotion intervention; intervention; musculoskeletal disease; neck; neck pain; neck-specific exercise; occupational health; office worker; productivity; workplace

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The impact of workplace ergonomics and neck-specific exercise versus ergonomics and health promotion interventions on office worker productivity: A cluster-randomized trial

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Objectives Using an employer's perspective, this study aimed to compare the immediate and longer-term impact of workplace ergonomics and neck-specific exercise versus ergonomics and health promotion information on health-related productivity among a general population of office workers and those with neck pain.

Methods A prospective one-year cluster randomized trial was conducted. Participants received an individualized workstation ergonomics intervention, combined with 12 weeks of either workplace neck-specific exercises or health promotion information. Health-related productivity at baseline, post-intervention and 12-months was measured with the Health and Work Performance Questionnaire. Intention-to-treat analysis was performed using multilevel mixed models.

Results We recruited 763 office workers from 14 organizations and allocated them to 100 clusters. For the general population of office workers, monetized productivity loss at 12 months [AU$1464 (standard deviation [SD] 1318) versus AU$1563 (SD=1039); P=0.023]; and presenteeism at 12 months [2.0 (SD 1.2) versus 2.4 (SD 1.4); P=0.007] was lower in the exercise group compared to those in the health promotion information group. For office workers with neck pain, exercise participants had lower sickness absenteeism at 12 months compared to health promotion information participants [0.7 days (SD 1.0) versus 1.4 days (SD 3.1); P=0.012], despite a short-term increase in sickness absenteeism post-intervention compared to baseline for the exercise group [1.2 days (SD 2.2) versus 0.6 days (SD 0.9); P<0.001].

Conclusion A workplace intervention combining ergonomics and neck-specific exercise offers possible benefits for sickness presenteeism and health-related productivity loss among a general population of office workers and sickness absenteeism for office workers with neck pain in the longer-term.

Key terms absenteeism; efficiency; neck pain; musculoskeletal disease; occupational health.

The annual prevalence of neck pain among office workers in Australia has been reported to be as high as 82% (1, 2). Neck pain is recurrent and chronic in nature (3) and a leading cause of disease burden in Australia (4). Importantly for employers, neck pain is associated with diminished productivity among office workers (5, 6). Employers of office workers have a legal responsibility, and a vested interest, to minimize the potential negative financial impact of neck pain. Thus, reducing the financial impact of health-related productivity loss among office workers will likely be a worthwhile business consideration for employers.

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Workplace health promotion has shown encouraging effects on worker health-related productivity (7, 8). The scope of workplace health promotion interventions is broad, encompassing the physical and psychosocial aspects of the individual worker and the workplace. Management of workplace ergonomics can optimize an asymptomatic office worker's environment with positive productivity results (9). However, ergonomic interventions, like rest breaks or equipment modifications, for office workers with pain demonstrated no clear productivity benefit (10). Similarly, the evidence for workplace exercises to improve physical capacity is mixed, with strong evidence for reducing neck pain but not for productivity gains (11, 12). Nevertheless, combination interventions like educational strategies with workplace modifications can reduce sickness absenteeism in workers with neck pain (13). Hence, there is a need for more evidence of productivity impact to facilitate employer decision-making processes regarding implementation of workplace health interventions for office workers.

Providing ergonomic solutions to manage and prevent work-related health concerns is current industry best practice in Australia (14). A combination of workplace ergonomics and neck-specific exercise training (EET) to improve health-related productivity among office workers has not been studied. This combination may potentially lead to productivity benefit as the workplace and physical ability of the office worker are both optimized. The main aim of this study is to compare productivity outcomes of EET versus ergonomics and health promotion information (EHP) in a general population of office workers with or without neck pain using a cluster-randomized trial. Three productivity outcomes of the monetary value of health-related productivity loss, sickness absenteeism, and sickness presenteeism were considered. The second aim was to investigate if the two combinations tested had immediate (12 weeks) and longer-term benefits (12 months) for individual participants. The third aim was to determine the effects of the interventions specifically for individual office workers with neck pain at baseline. We hypothesized the EET would be more effective than the EHP intervention in improving health-related productivity outcomes among individual office workers in the short and longer-term with greater effects for those with neck pain at baseline.

Methods

Design

A prospective one-year parallel two-armed balanced cluster-randomized trial (ACTRN12612001154897) approved by the Human Ethics Unit of the University of Queensland (2012001318) was conducted from May 2013 to July 2016

The protocol has been published (15) and recommendations from the CONSORT extension for cluster trials were observed for reporting (16). Monetary values were reported in 2015 Australian dollars (AU$).

Recruitment and participants

Public and private organizations employing office workers in Queensland, Australia, were targeted and enrolled sequentially (15). The trial was presented as a general health improvement initiative. Internal emails and information sessions were used for recruitment. Office workers ≥18 years, working ≥30 hours weekly, without specific medical conditions and contraindications to exercise were eligible (15). Participants provided informed consent.

Clustering and cluster-randomization

Participants were clustered by building, floor, or work unit in descending order until optimal cluster size (5–8) was reached, to allow sufficient supervision and facilitation for the EET. Larger clusters were created for open-planned offices. Clustering allows homogeneity within- and heterogeneity between-clusters, reduces contamination (17–19), and is a realistic implementation of workplace interventions. An even number of clusters were created within each organization.

A blinded statistician assigned clusters to either intervention using a randomly generated number sequence (sets of four). Participants were notified of their assignment after completion of baseline assessments and shortly before interventions commenced. This was repeated at each organization.

Outcome measures

An online survey was used to collect participant-reported information.

Primary outcome

Self-reported health-related productivity loss was measured at baseline, 12 weeks, 6, 9, and 12 months using the World Health Organization's Health and Work Performance Questionnaire (HPQ), and hereafter referred to as productivity loss. This paper reports data from the main follow-ups of baseline, 12-weeks (post-intervention) and 12-months. Good agreement with work performance measures from an employer's perspective has been reported for this scale (20, 21).

Monetized productivity loss was calculated using absenteeism and presenteeism sections in the HPQ using an employer's perspective. Whole and part (0.5) work days missed due to personal health reasons in the last 28 days were totaled and represented absenteeism [Abs(days)]. Self-reported performance [0 (worst) to 10 (best)] in the past 28 days was subtracted from 10 to represent presenteeism. Work days missed attributable to presenteeism [Pres(days)] was tabulated by converting presenteeism levels to a percentage [Pres(%)], and computing:

$$\text{Pres(days)} = \text{Pres(\%)} \times [20\text{-Vacation(days)} - \text{Abs(days)}]$$

Lastly, monetized productivity loss was estimated, using:

$$\text{Productivity loss(\$)} = [\text{Abs(days)} + \text{Pres(days)}] \times \text{Daily income}$$

Neck pain

Neck pain in the preceding week was determined using a body diagram and a scale from 0 (no pain) to 9 (worst symptoms). Participants who scored ≥3 at baseline were defined as having neck pain.

Other measures

Information of gender, age, body mass index, medical conditions, annual income, office worker category type (1), daily work-related computer use duration, and job satisfaction [levels 1 (lowest) to 7 (highest)] were obtained at baseline. Organization information (industry sector and size) was recorded.

Interventions

Interventions occurred during work time. All participants received a workstation ergonomics assessment by a blinded physiotherapist or occupational therapist. An observational checklist with moderate to good reliability was used (22). Based on these findings, participants received an individualized best-practice ergonomic intervention (10, 14, 23, 24).

Workplace ergonomics and neck-specific exercise training

EET participants additionally received an individualized progressive neck-specific exercise program using resistance bands and weights for 12 weeks (15). Participants exercised at work in groups for 20 minutes, three times weekly. Two sessions in the first week were supervised by a physiotherapist to allow time for explanation, demonstration and practice of exercises. Subsequently, one weekly session was supervised. The physiotherapist documented attendance at supervised sessions and participants logged their attendance at unsupervised sessions in an exercise diary. Equipment to continue the regime independently was provided when the program ended.

Workplace ergonomics and health promotion information

EHP participants additionally received a weekly series of health promotion seminars (appendix 1, www.sjweh.fi/show_abstract.php?abstract_id=3760), conducted by a health professional, each lasting an hour for 12 weeks to ensure parity of intervention time across groups. Specific information regarding exercise was not included. Attendance was recorded by the health professional.

Intervention delivery

Participants could attend sessions for another cluster of the same intervention if they were unable to attend their scheduled session.

Power calculation

Sample size was calculated using an employer's perspective. Productivity loss reductions needed to be at least AU$896.80 for employers to break-even from costs of employee wages for participation during work hours. Based on an intra-class correlation of 0.02, a mean cluster size of six, and a loss of 10% at follow-up, 640 participants were needed. Before recruitment ended, the sample was inflated to 720 because of higher attrition at 25%, due to more than expected organizational restructuring.

Statistical analysis

All statistical analysis was conducted with Stata version 14 (Stata Corporation, College Station, TX, USA). Intention-to-treat (ITT) analysis was conducted. Baseline characteristics were analyzed for individual-based differences between groups using 2-sample t-tests for continuous variables, and χ^2 statistics for categorical variables. Variables with individual-based differences between groups were considered for potential model adjustments. Other model adjustments included were baseline productivity levels, age, gender, baseline neck pain, an intervention-time interaction, and intervention adherence.

Mixed-effects hierarchical models were constructed using three different outcome variables; monetized productivity loss, absenteeism, and presenteeism. These were used due to the longitudinal design of the study and to accommodate missing data points, which occur frequently in longitudinal studies (25). In addition, mixed-effects models also contain fixed and random effects, appropriate for the design of this study as the recruitment strategy was based on organizations and randomization based on clusters. Hierarchical or multilevel models accounted for the nesting of individual participants within randomization clusters for intervention assignment and employment organizations (26). Three levels of nesting were used. The lowest level was the individual, followed by the randomization cluster for intervention assignment, with the highest level being the employment organization. Nesting levels were specified as random effects in the modeling and intervention group specified as a fixed effect and viewed as an explanatory variable. Different models were performed depending on the nature of the productivity outcome being investigated as the dependent variable. Specifically, for the monetized value of productivity loss – multilevel mixed effects generalized linear model (meglm; gamma-family and log-link), for absenteeism – multilevel mixed effects poisson regression (mepoisson), for presenteeism – multilevel mixed effects ordinal regression (meologit).

Post-hoc pairwise comparisons were conducted to determine between- and within-group differences at 12-week and 12-month follow-ups. The following equation illustrates the multilevel mixed effects poisson regression modeling performed for absenteeism as an example.

$$\text{Abs(days)} = \text{Constant} + \beta_1 \text{ Intervention assignment} + \beta_2 \text{ Abs (days at baseline)} + \beta_3 \text{ Neck pain (at baseline)} + \beta_4 \text{ Age} + \beta_5 \text{ Gender} + \mu_1 \text{ Individual} + \mu_2 \text{ Cluster} + \mu_3 \text{ Organisation} + \varepsilon$$

Variables included in models were examined for multicollinearity using variance inflation factor (VIF). Collinearity was deemed to be an issue if VIF >10 (27, 28).

Table 1. Baseline characteristics of participants by intervention group. *Note:* Not all numbers reported correspond to group totals because of missing data.

Characteristic	EET (N=381) N (%)	EHP (N=382) N (%)
Gender (female)	222 (58.3)	230 (60.2)
Occupation category		
Manager / senior official	67 (17.6)	75 (19.6)
Professional	111 (29.1)	113 (29.6)
Associate professional / technical Occupation	38 (10.0)	41 (10.7)
Administrative / secretarial Occupation	115 (30.2)	118 (30.9)
Personal service	12 (3.1)	7(1.8)
Others	25 (6.6)	19 (5.0)
Number of medical conditions reported (count)		
0	227 (59.6)	199 (52.1)
1	99 (26.0)	107 (28.0)
2	28 (7.3)	45 (11.8)
3	12 (3.1)	15 (3.9)
≥ 4	2 (0.5)	7 (1.8)
Neck case status	91 (24.8)	109 (29.2)
Time using computer at work		
<6 hours / day	67 (9.1)	57 (7.7)
≥6 hours / day	301 (40.5)	316 (42.7)

Results

Organizations, participants and participation

Figure 1 depicts trial events and participant numbers at each stage. Of 21 organizations approached, 14 were enrolled (5 private and 9 public). A total of 4029 employees were emailed an invitation to participate. When eligibility was unclear, members of the research team discussed and reached consensus. Finally, 763 participants were recruited and assigned to either arm. Participants' characteristics were determined to be similar to eligible employees using information provided by the organization (gender, age, income, and location).

The mean ages of EET and EHP participants were 42.4 [standard deviation (SD) 11.1] and 43.0 (SD 10.3) years, respectively. The average incomes of both groups (EET: AU$90 227; SD 43 300 and EHP: AU$89 286; SD 33 570) were higher than the Australian average annual income of $53 045 (29). Individual baseline job satisfaction levels were similar between-groups at baseline (EET: 4.98, SD 1.14 and EHP: 4.88, SD 1.10). There were no individual-based differences between groups for other baseline characteristics (table 1).

Fifty clusters were formed for each intervention group (appendix 2, www.sjweh.fi/show_abstract.php?abstract_id=3760). Mean cluster size was 8.4 for the EET group and 8.5 for the EHP group, without between-group differences. Appendix 2 details organization size, sector, participant incomes, recruitment rates, number of clusters, participant numbers and cluster sizes for each organization. Mean income was higher in the private sector (private: AU$101 708; SD 59 635 versus public: AU$80 726; SD 20 692; P-value<0.001). Only one organization achieved high recruitment at 77.8% (30).

Adherence

Self-reported adherence at unsupervised exercise sessions was recorded in an exercise diary of which 270 were returned. For EET participants who did not submit diaries, their adherence at unsupervised sessions was predicted based on their adherence at supervised sessions and applying the relationship between supervised (recorded by physiotherapist) and unsupervised adherence data for those who submitted diaries. Adherence (including predicted adherence for those who did not return diaries) at all sessions conducted as a percentage of 100 represented adherence. There were no between-group differences in adherence (appendix 2).

Attrition

Post-intervention productivity data was provided by 76.4% of participants (N=583) who had higher baseline

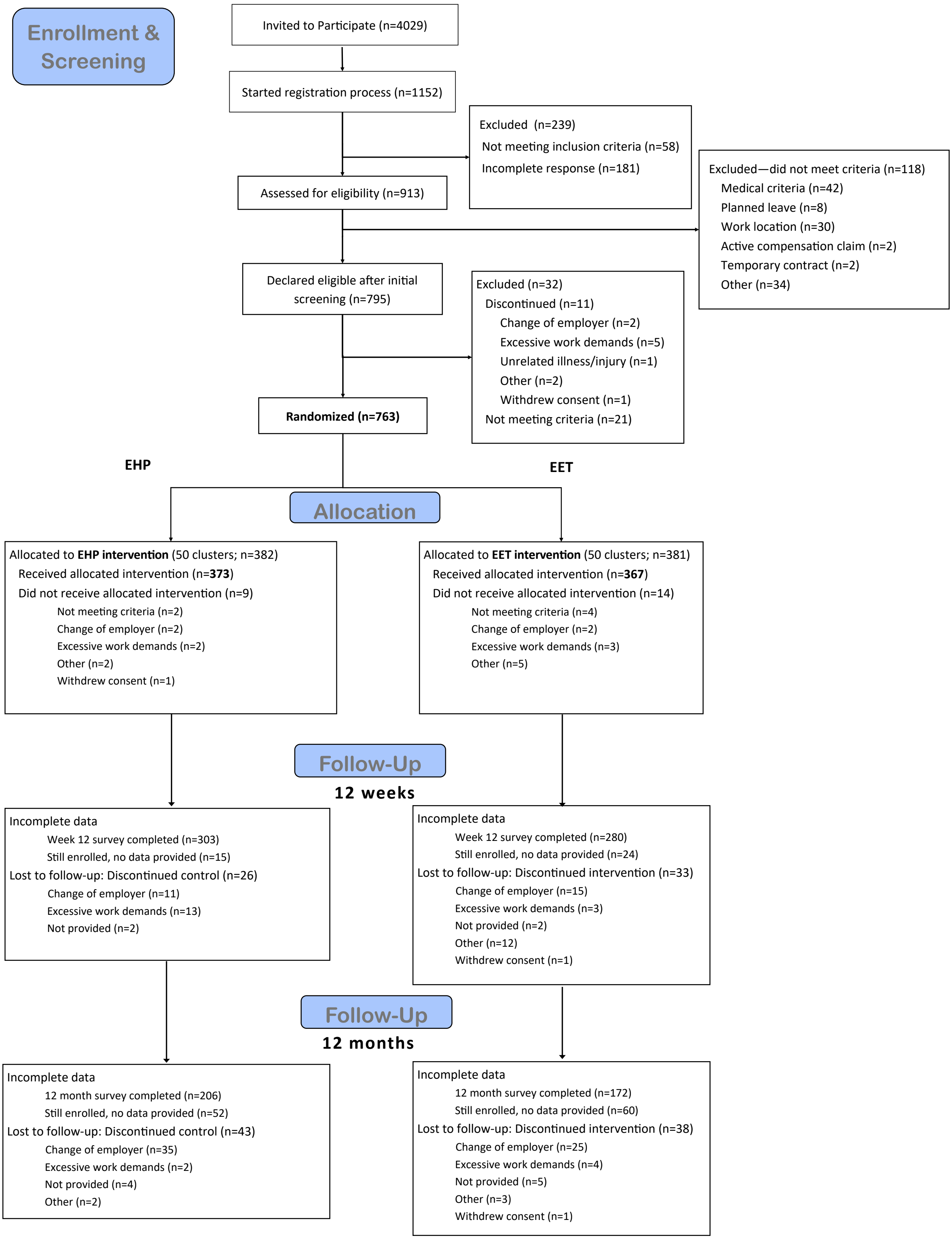

Figure 1. CONSORT flowchart of participants.

job satisfaction compared to those who did not provide data. At 12-month follow-up, 49.5% of participants provided productivity information (N=378). Of those who did not provide the 12-month productivity data, 15.6% had a change of employer (N=60). Participants who provided data at 12-month follow-up were older, had more medical conditions, and higher baseline job satisfaction compared to those who did not. Multiple imputations of missing data were not performed because outcome data was not missing at random.

Productivity results for office workers general population

Table 2 states unadjusted means of productivity outcomes and modelling results. Diagnostic tests did not indicate multicollinearity issues in modeling analysis.

Monetized value of productivity loss

Monetized productivity loss was not different between-groups at baseline and 12 weeks (figure 2). The EET compared to the EHP group had lower monetized productivity loss at 12 months of $276 (95% CI -474– -42). Monetized productivity loss increased at 12-weeks by $268 (95% CI 64–501) for the EET group and by $281 (95% CI 70– 520) for the EHP group, with respect to baseline. At 12-months, the EHP group demonstrated an increase in productivity loss of $436 (95% CI 182–731), compared to baseline.

Absenteeism

In this model, baseline neck pain was positively associated with absenteeism (coefficient=0.345; 95% CI 0.130 – 0.561). No between-group differences in absenteeism were detected. There were within-group increases of absences at 12 weeks of 0.264 days (95% CI 0.077–.452) and 0.202 days (95% CI 0.014–0.389), compared to baseline for EET and EHP intervention groups, respectively. Similarly at 12 months, both EET and EHP groups had increases in absences compared to baseline by 0.223 days (95% CI 0.004–0.443) and 0.472 days (95% CI 0.266–0.678), respectively.

Presenteeism

At baseline and 12-weeks, presenteeism levels were not different between-groups. In comparison to the EHP group, the EET group reported lower levels of presenteeism at 12-month follow-up by 0.563 (95% CI -0.973– -0.154). In addition, there were no within-group differences at 12-week and 12-month follow-ups compared to baseline for both groups.

Table 2. Unadjusted means [standard deviation (SD)] of monetized productivity loss, absenteeism, presenteeism in the last 28 days, and results of within- and between- groups comparisons by follow-up time-points. Models adjusted for baseline levels of dependent variable, age, gender, baseline neck pain (except models for participants with neck pain), intervention-time interaction, and intervention adherence. Only coefficients of intervention effects are presented. [EET=workplace ergonomics & neck-specific exercise training; EHP=ergonomics & health promotion information.]

Outcome	Observations	EET	EHP	Model results		
				Between-group comparisons (reference = EET)	Within-group comparisons (reference = baseline)	
					EET	EHP
		Unadjusted means (SD)	Unadjusted means (SD)	Contrast size (95% CI)	Contrast size (95% CI)	Contrast size (95% CI)
Monetized productivity loss ($AUD)	1653					
Baseline		$1,393 ($1,029)	$1,463 ($941)	-$70 (-228–109)		
12 weeks		$1,462 ($1,166)	$1,524 ($1,074)	-$73 (-256–139)	$268 (64–501) [b]	$282 (70–520) [b]
12 months		$1,464 ($1,318)	$1,563 ($1,039)	-$276 (-474– -42) [a]	$171 (47–425)	$436 (182–731) [b]
Absenteeism (days)	1711					
Baseline		0.6 (1.4)	0.6 (1.2)	0.046 (-0.199–0.291)		
12 weeks		0.8 (1.9)	0.8 (2.0)	0.109 (-0.140–0.358)	0.264 (0.077–0.452) [b]	0.202 (0.014–0.389) [a]
12 months		0.8 (2.0)	0.9 (2.0)	-0.203 (-0.487–0.081)	0.223 (0.004–0.443) [a]	0.472 (0.266–0.678) [b]
Presenteeism (0–10 score)	1702					
Baseline		2.1 (1.3)	2.3 (1.3)	-0.118 (-0.368–0.133)		
12 weeks		2.1 (1.2)	2.3 (1.3)	-0.147 (-0.479–0.184)	0.006 (-0.294–0.306)	0.035 (-0.254–0.324)
12 months		2.0 (1.2)	2.4 (1.4)	-0.563 (-0.973–0.154) [a]	-0.208 (-0.561–0.145)	0.237 (-0.091–0.566)
Absenteeism for office workers with neck pain (days)	460					
Baseline		0.6 (0.9)	0.8 (1.0)	-0.111 (-0.569–0.346)		
12 weeks		1.2 (2.2)	1.0 (2.3)	0.246 (-0.192–0.685)	0.650 (0.293–1.007) [b]	0.291 (-0.012–0.596)
12 months		0.7 (1.0)	1.4 (3.1)	-0.696 (-1.237–0.155)	0.158 (-0.308–0.623)	0.742 (0.405–1.080) [b]

[a] P<0.05.
[b] P<0.01.

Productivity results for office workers with neck pain

For office workers with neck pain, there were no between-group differences at baseline and 12 weeks for absenteeism, but EET participants had lower absenteeism at 12 months compared to EHP participants by 0.696 days (95% CI -1.237– -0.155). There were within-group increases in absenteeism at 12-week follow-up for the EET group of 0.650 days (95% CI 0.293–1.007) and at 12-month follow-up for the EHP group of 0.742 days (95% CI 0.405–1.080), relative to baseline. No between- or within-group differences were found for presenteeism and monetized productivity loss among participants with neck pain at all follow-ups.

Adverse events

Early in the study, two participants reported resistance band failure, resulting in a change from latex resistance bands to tubing from the same manufacturer (Theraband®). Two particpants reported musculoskeletal symptoms. One of these incidents was due to the exercise program, and the other, muscle function testing for individualization of training load. Following follow-up with a physiotherapist and subsequent modification of exercises until symptom resolution, these participants continued participation without issue.

Discussion

The EET demonstrated productivity benefits in several ways. The monetized value of productivity loss was lower for the EET group compared to their EHP counterparts at 12 months. This was primarily driven by lower presenteeism observed in the EET group. Additionally for those with neck pain, EET participants had higher levels of absenteeism post-intervention compared to baseline, but lower absenteeism at 12 months compared to EHP group participants. Hence, worker productivity loss management through a combination workplace ergonomics and neck-specific exercise training for office workers is a sound financial investment and business strategy with longer-term gains. Our hypothesis that EET can benefit office worker productivity, a tangible outcome valued by employers, when compared to EHP is supported by these findings.

This study is unique compared to previous related studies. Blangsted and colleagues (12) reported that a 12-month workplace neck and shoulder resistance exercise training for office workers did not benefit absenteeism and work ability post-intervention and Justesen and colleagues (31) found that a one-year workplace individualized physical exercise training of adequate adherence combined with sufficient leisure-time physical activity

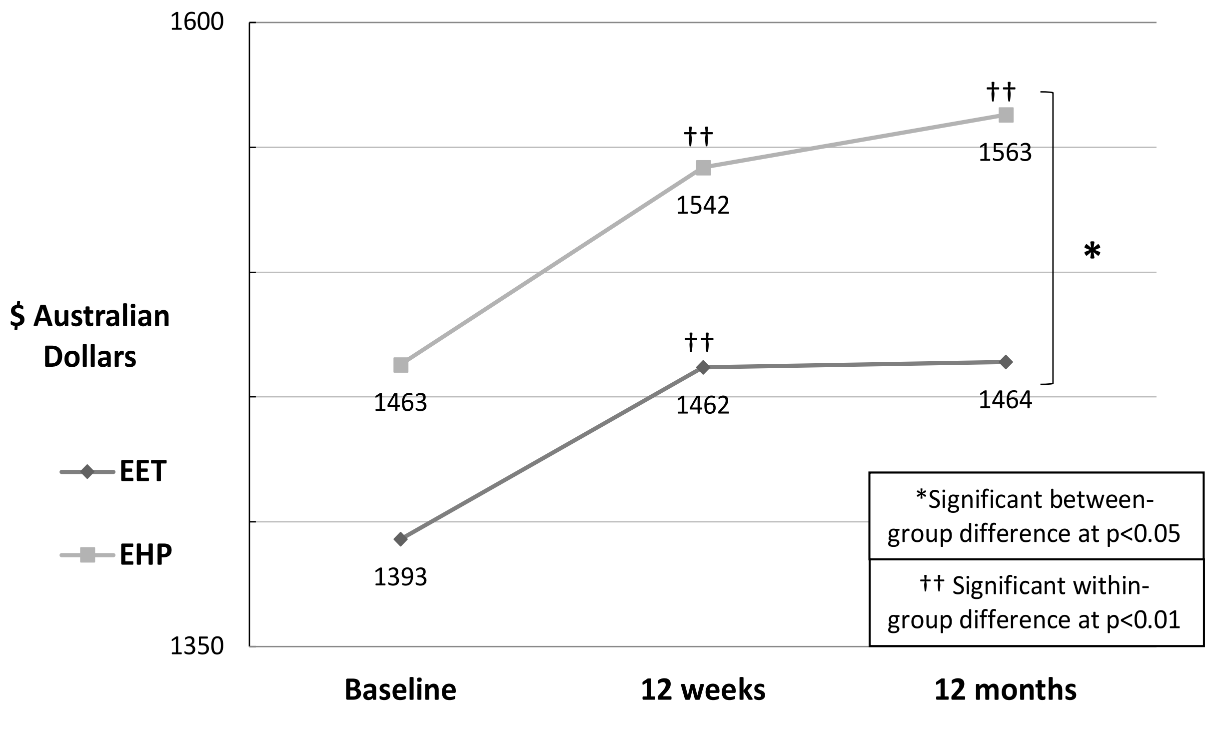

Figure 2. Monetized productivity loss among general office workers in the past 28 days by intervention group over time.

improved absenteeism and presenteeism. The key differences between these studies and this present one are the duration and nature of the intervention. This study implemented a shorter intervention of 12 weeks, with continuance of the regime facilitated through distribution of equipment for independent activity. Secondly, both post-intervention and longer-term impact from the interventions was investigated as the study's secondary objective. This is in contrast with related studies that focused on evaluating immediate impacts (12, 31). Considering the recommended 10-week minimum for effective workplace exercise interventions for neck, shoulder, and low-back pain (32), an employer is more likely to view a 12-week program as more cost-effective than a 12-month intervention. The last and potentially most significant difference is the innovative combination of workplace ergonomics and neck-specific exercise training in this study. This echoes the recommendation of Pereira et al (33) that workplace interventions for worker productivity augmentation need to be multidimensional involving exercise and other components, for example workplace ergonomics as in this study.

There were some unexpected findings arising from this study. Firstly, positive productivity results were only demonstrated between-groups at 12-months. This is possibly because of the HPQ's 28-day recall, resulting in the reporting of productivity levels post-intervention not reflecting the maximum benefit of the EET. Secondly, the general population of office workers had higher levels of absenteeism at 12-weeks when compared to baseline regardless of intervention group. This result may be a reflection of confounding factors that were not accounted for. For example, unmeasured socio-economic differences (34) and the impact of seasonal variation as intervention delivery scheduling coincided with the flu season in Australia. Additionally, for those with neck pain, the EET intervention was associated with an intermediate worsening of absenteeism levels (0.650 days compared to baseline). This negative result did not persist at 12 months for those with neck pain in the EET group. Although, the positive influence on presenteeism from the EET intervention in the general population of office workers can potentially offset this result as the cost of absenteeism is a minor component of productivity loss in office workers, when compared to presenteeism (35). Nevertheless, our hypothesis was partially supported in that EET decreases absenteeism in the longer-term for office workers with neck pain compared to the EHP group.

Strengths

This study had several strengths in its design, implementation, analysis, and generalizability. A key design strength was that it was powered using productivity measures that are important interests for the employer as primary outcomes. This contrasts with several previously published studies (12, 36) which may explain the positive findings found. Using an employer's perspective is essential to ensure direct relevance to a crucial stakeholder of such workplace interventions. Additionally, the use of the HPQ to estimate productivity levels and enabled both absenteeism and presenteeism to be estimated. Previous studies have used single-item question (36, 37) or measures designed for symptomatic populations (38, 39), which may have contributed to a lack of productivity benefit.

The EET intervention was designed for the office worker population based on best available evidence for the prevention and treatment of neck pain at the workplace (10, 11, 23). It addressed the physical requirements of office work and was matched to the individual's capabilities (40). Also, the interventions delivered in this study are effective, feasible and sustainable, and have potential for immediate application, which should encourage employers to implement similar programs. Lastly, the results were based on individually obtained data from public and private enterprises and derived from analysis of individual results accounting for the clustering of participants and intervention adherence, as opposed to aggregated clustered data.

The results from this study may be generalizable to office workers with and without neck pain in other settings due to the following reasons. First, participating companies ranged in manpower size from <1000 to >10 000 employees and were from both the private and public industry sectors. Second, the trial was presented as a general health improvement initiative to prevent participant response bias favoring those with specific health conditions. Third, asymptomatic participants were considered in this study. Fourth, data of mean age, gender distribution and prevalence of neck pain in the last week obtained in this study were comparable to figures from a previous survey of 934 complete responses from 8000 public service employees in office-based work throughout public service in Australia (1).

Limitations

The study had some limitations. The follow-up rate at 12-months was lower than expected at 49.5%. However, discontinuation and incomplete information, and characteristics of participants who did not provide follow-up data were provided to minimize bias. It is also possible, that differing participation motivation contributed to results but this was not assessed. However, this is a limitation that all research studies in various settings will experience. Secondly, the human capital approach was used to quantify the monetary value of productivity loss, which can be an overestimation compared to the friction cost approach (41). Due to the 28-day recall period in the HPQ, this overestimation is likely to be small. Thirdly, the usage of the employer's perspective does not account for participants making up for missed work days with overtime on other days, which could have potentially biased absenteeism findings to higher levels. Another study limitation concerns the presenteeism measure used, which is not health-specific and is a general view of reduced at-work performance. This means that the results obtained may potentially overestimate actual presenteeism (42). Nevertheless, as the results were based on repeated measures from the same individual, this potential bias is minimized. Finally, the findings from this study are derived from self-reported measures. However, the office worker population with a heterogeneous mix of job positions with varying cognitive work demands does not have validated objective measures of worker productivity. Thus, despite self-rated measures oftentimes being disputed for accuracy, the choice of the HPQ was fitting due to considerations discussed earlier.

Direction for future research

The actual economic value of the EET intervention in settings where office workers do not routinely receive workplace ergonomics support could be verified using "usual practice" in such settings for comparision. Thus, future studies should have a true control rather than an active comparator like the EHP tested in this study. Moreover, the additive value of the neck-specific exercise training should be evaluated in future by comparing the neck-specific exercise training to best practice ergonomic standards at other workplaces in Australia. These suggestions can provide clarity on the actual benefit of the combined workplace ergonomics and neck-specific exercise training and the exact impact from the exercise component.

Concluding remarks

This study provides evidence of possible productivity benefits in a general population of office workers and those with neck pain from a combination workplace intervention of ergonomic management and neck-specific exercise training when compared to a combination of ergonomics and health promotion information in the study context. Hence, employers of office workers in Australia can implement a similar exercise intervention to potentially improve the employee productivity, whereas employers in other jurisdictions may need to implement the combined workplace ergonomics and neck-specific exercise training to achieve similar results.

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