A workplace exercise versus health promotion intervention to prevent and reduce the economic and personal burden of non-specific neck pain in office personnel: A cluster randomized controlled trial

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INTRODUCTION
Musculoskeletal disorders such as neck pain are a common threat to productivity in office workers. In the Netherlands, 26% of computer users with regular or prolonged neck/shoulder and/or hand/arm symptoms reported that their symptoms affected their productivity (van den Heuvel et al 2007). While in Sweden, 13% of computer workers with neck or neck/shoulder pain reported productivity effects at work with the average reduction in productivity in those experiencing daily pain of nearly 22% (Hagberg et al 2002).

Ergonomic interventions, considered to be industry best practice, appear to positively impact on outcomes relevant to industry – productivity and absenteeism. In a Scandinavian study, workers receiving ‘current best practice ergonomic intervention’ reported significantly improved productivity (Martimo et al 2010) and had significantly fewer sick days compared with the control group (mean 17.3 versus 23.3 days, at 12 months) (Shiri et al 2011). While these outcomes are beneficial for the organisation, there is strong evidence that workplace adjustments alone have no effect on neck/upper extremity musculoskeletal health outcomes of individuals (Brewer et al 2006, Kennedy et al 2010). In contrast, neck and shoulder girdle exercises have demonstrated benefits to the individual. Two recent systematic reviews found strong evidence to support the positive effect of muscle strengthening and endurance exercises for controlling neck pain in office workers (Coury et al 2009, Sihawong et al 2011). The exercise intervention was effective in reducing neck pain in office workers with severe pain by 79%, well beyond that attained by aerobic exercise (leg-bicycling) or the reference intervention (Andersen et al 2008b). The exercises were effective in the long-term for those
symptomatic at baseline (Andersen et al 2008b). This same exercise protocol was also more effective in preventing the development of neck–shoulder symptoms in those asymptomatic at baseline than an all-round physical exercise intervention (Blangsted et al 2008). However the impact of these exercises on work productivity is unclear.

While there is evidence that multi-modal interventions have additive clinical benefits for chronic neck pain (Miller et al 2010) there is a lack of quality studies investigating multi-modal interventions for the primary and secondary prevention of neck pain. The majority of studies test single interventions but as ergonomic measures are now considered best practice, it is reasonable to expect that the addition of a validated exercise intervention involving progressive conditioning (strength/endurance) of neck and shoulder girdle muscles will demonstrate additional benefits for office workers with neck pain and those at risk of developing neck pain. We postulate that the addition of a neck exercise intervention (conditioning the worker) to best practice ergonomic approach (optimising the work environment) will result in improved productivity and reduced neck pain severity in those symptomatic at baseline. It is also hypothesised that this multi-modal approach will reduce the risk of neck pain in those asymptomatic at baseline. If new occupational health interventions are to be widely adopted and implemented by industry, gains in both productivity and pain need to be demonstrated.

This research will determine if the addition of a workplace-based neck exercise program to a best practice ergonomic intervention:

1. Reduces productivity losses in office workers with and without neck pain;
2. Reduces the risk of developing neck pain in office workers without neck problems;
3. Reduces the severity of neck pain in office workers with neck problems.

**METHOD**

**Design**

This study will be a prospective parallel arm cluster-randomized controlled trial with a best practice ergonomic and exercise training (EET) intervention group and a combined best practice ergonomic and health promotion information (EHP) control group (Figure 1).
Invitation to eligible office personnel

Baseline measures: Productivity, pain severity, neck disability, quality of life, physical activity levels, exercise self-efficacy, stage of change, muscle performance

Randomisation
(N = 640 participants)

Control Group
(N = 320)

Ergonomic & Health Promotion intervention 12 weeks

Productivity, pain severity, neck disability, quality of life, physical activity levels, exercise self-efficacy, stage of change, muscle performance, adherence to exercise

Productivity, Pain, disability, adherence to exercise

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Productivity, pain severity, neck disability, quality of life, health beliefs, Physical activity levels, exercise self-efficacy, exercise stage of change, muscle performance, adherence to exercise

Intervention group
(N = 320)

Ergonomic & Exercise training intervention 12 weeks

Productivity, pain severity, neck disability, quality of life, physical activity levels, exercise self-efficacy, stage of change, muscle performance, adherence to exercise

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3 months follow up

6 month follow up

9 month follow up

12 month follow up
Participants, therapists, centres

Employees will be recruited from organisations employing large numbers of office personnel from government and non-government industry sectors. Eligible employees will be any office worker, aged over 18 years, who work more than 30 hours/week performing office work. Exclusion criteria will be pregnancy, health conditions such as previous trauma or injuries to the neck, specific pathologies (e.g., congenital cervical abnormalities, stenosis, radiculopathy) or inflammatory conditions (e.g., rheumatoid arthritis), any history of cervical spine surgery or if exercise is contraindicated by their medical practitioner for any reason (e.g., uncontrolled hypertension, angina). Employees will be encouraged to continue with any usual exercise or sporting activity for the duration of the research. To avoid potential bias with only symptomatic cases volunteering, the exercise intervention will be promoted also as a preventive health initiative rather than an intervention targeting those with neck symptoms. Qualified health professionals will deliver all interventions (ergonomic, exercise and health promotion).

Interventions

Both the exercise training intervention group and health promotion group will receive an individualised current best practice ergonomic intervention conducted by an experienced health professional. The ergonomic intervention will involve an initial one-hour assessment and a maximum of one follow-up appointment. Criteria for the ergonomic intervention will be based on current empirical evidence and best practice using Australian government guidelines (Comcare 2008). Any necessary equipment will be purchased through the research project’s funds thereby removing financial barriers and ensuring implementation of the recommended interventions.

Exercise training (intervention group)

Participants allocated to the training intervention group will also receive a progressive exercise program shown to be effective in reducing neck pain in office workers (Andersen et al 2008b, Blangsted et al 2008). The exercises will be performed at the workplace in small
groups of employees, for 20 minutes 3 times a week for 12 weeks. A standard set of exercises consisting of three exercises each for the neck and shoulder girdle will be prescribed to all employees but their implementation and progression will be within the specific capabilities of the individual. Upper cervical flexion (utilised as a warm up exercise), and progressive resisted lower cervical flexion and extension exercises, will be performed in sitting utilising varying resistance elastic bands with higher resistances obtained by combining the bands in parallel or stronger resistance (Figure 2). Shoulder girdle exercises will include bilateral shoulder flexion and abduction (in the plane of the scapula) to 90° (Figure 3), and bilateral reverse flyes (Figure 4) using progressive resistance provided by dumbbells and resistive elastic bands. Training load for each individual will be based on their one-repetition maximum (1-RM) that will be regularly re-evaluated to ensure appropriate exercise progression. Each training session will commence with a warm up of ten repetitions at a load of 50% of 1-RM for each exercise. This will be followed by three sets of 10-20 repetitions of each exercise at 60-85% of their 1-RM (Mayhew et al 1992). Progression of exercise in this manner is within guidelines suggested for the principles of periodization and progressive overload (Kraemer et al 2002). The exact load prescribed for any individual worker, for any of the exercises at any stage of the exercise program, will be a load at which the individual is able to perform the exercise with control, particularly with respect to their postural orientation during the exercise. This is in accordance with contemporary approaches to exercise for the management of spinal pain (Jull et al 2008).

Figure 2: Lower cervical flexion (2A) and cervical extension (2B) exercises using graded resistive elastic bands
Figure 3: Resisted shoulder flexion (3A) and abduction (in the plane of the scapula) (3B) using dumbbells

Figure 4: Reverse flyes against graded resistive elastic bands

The risk of adverse events will be minimised by the health professional supervising one exercise session per week to ensure the exercises are being performed safely and within the employee’s capabilities and pain tolerance. Compliance with the 12-week exercise intervention will be encouraged by the attending health professional. Employees will
maintain a weekly diary to record exercise quantity, intensity and frequency. Adherence with the exercise intervention on completion of the 12-week intervention will be encouraged with fortnightly reminder emails. A written detailed copy of each exercise technique, load intensity, and the number of sets and repetitions will be given to each employee to facilitate compliance during the 12-week intervention.

**Health promotion (control group)**

To ensure parity in time with those in the intervention group, employees will be invited to attend health promotion information sessions for one hour per week for 12 weeks in addition to the ergonomic intervention. Topics will include information on healthy eating, stress management, weight loss, relaxation, and cessation of smoking. There will be no structured physical activity recommendations or specific information on exercise other than the importance of staying active. Attendance to these sessions will be documented to determine participation rate.

**Outcome measures**

*Primary outcome:*

Productivity Loss will be measured in monetary units calculated using the World Health Organisation’s Health and Productivity Questionnaire (HPQ), a validated instrument for measuring self-reported absenteeism and presenteeism rates that is also able to measure the workplace costs of illness (Kessler et al 2003). This measure has demonstrated excellent reliability, validity, and sensitivity to change (Kessler et al 2004). Self-reported absenteeism will be measured by the number of days and part days missed from work in the previous four weeks and converted to a monetary value using the employee’s wage rate (including on-costs). Presenteeism will be measured by the HPQ by asking several memory priming questions around different aspects of job performance (e.g. quality of work, concentration). Following these questions, the respondent will be asked to rate the performance of an average person working in a similar job to their own on a scale of performance from 0-10 (worst to best). The respondents then rate their own performance over the last 4 weeks on the same scale. Published algorithms will be used to convert the self-rated scale into a monetary value for lost productivity due to presenteeism based on the employee’s wage rate (Kessler et al 2004). Total productivity loss will be calculated for each individual as the sum of the losses
due to absenteeism and presenteeism in Australian dollars. This outcome measure will be collected at baseline, immediately after the intervention and at three-monthly intervals for 12 months.

**Secondary outcomes:**

The severity of neck pain will be evaluated using pain intensity measures over the prior seven days and prior three months. A body map will be used to clarify the anatomical areas specified as the neck, shoulder and upper back regions. Employees will record the intensity of their worst and average symptoms for the previous three months and degree of pain over the previous seven days using a 10-point scale ranging from 0 (no pain) to 9 (worst possible pain) (Kaergaard et al 2000). The validity of this self-report scale has been confirmed in a sample of workers with clinical signs of neck-shoulder disorders (Kaergaard et al 2000) and the test-retest reliability reported to be good to excellent for average and worst pain (Brauer et al 2003). Activity restriction due to symptoms in each body region during the previous three months will also be recorded using the same scale. Our study will define cases as those who score $\geq 3$ on the 0-9 scale and non-cases as those who score from 0 to 2 on the seven-day symptom intensity question (Blangsted et al 2008, Zebis et al 2011). These outcome measures will be collected at baseline, immediately after the intervention and at three-monthly intervals for 12 months.

The number and severity of concurrent musculoskeletal pain sites will be determined using a body chart to indicate the anatomical regions of low back, hips, knees, ankles, elbows and hands. Employees will indicate the presence of symptoms at each site and then the intensity of symptoms using a 10-point scale ranging from 0 (no pain) to 9 (worst possible pain) during the previous seven days. An additional pain region will be defined when the reported pain intensity is three or more (Andersen et al 2010a). These outcome measures will be collected at baseline, immediately following the intervention and at 12 months follow up.

Cervical flexor/extensor isometric strength [Maximal Voluntary Contraction, MVC] then endurance will be measured with a dynamometer (Mecmesin BFG 1000N digital force gauge from SI Instruments Pty Ltd) attached to a seated frame. The thorax of the employees will be secured by the adjustable backrest of the frame and attached belt anteriorly. The mounted dynamometer will be height adjustable for accurate recording of extensor (application pad positioned at the occipital protuberance) and flexor (non-elastic strap at the level of the
forehead) muscle force. Employees will perform a standard warm-up of three sub-maximal repetitions followed by three trials of maximal contractions with 60s rest between each trial. The maximal value measured will be recorded as the MVC score. For the endurance test participants will be required to sustain an isometric effort at 50% of their MVC until task failure (no longer able to sustain the contraction). The duration for which the employee was able to sustain the contraction before task failure will be recorded as the endurance measure (O'Leary et al 2007, O'Leary et al 2012). During testing, standardised visual feedback (live force display) and verbal encouragement will be provided to the participants. These neck dynamometry measurements have been shown to have good to excellent test-retest reliability (ICC 0.7 - 0.99) (O’Leary 2005, Van Wyk et al 2010).

The MVC (kilograms) and endurance (seconds) of the shoulder abductors will be determined with free weights using a lateral arm raise to 90° shoulder abduction in scapular plane with the participant standing against a wall (Andersen et al 2010b). The maximal weight lifted with acceptable technique will be recorded as the 1-RM. Endurance will be determined by the number of times a weight 1kg lower than MVC can be raised and lowered. Measures of neck and shoulder muscle strength and endurance will permit evaluation of the impact of the exercise program on muscle conditioning of neck and shoulder girdle. The muscle strength and endurance measures will be collected at baseline, immediate and 12 months post-intervention.

Compliance to exercise during the 12 week structured intervention will be determined from the weekly diary completed by each participant in the EET. Regular adherence will be defined as participating at least once a week during the 12-week intervention (Andersen et al 2008a). On completion of the exercise training, adherence will be recorded with two questions administered electronically monthly to participants in the EET group. One question will ask about frequency of exercise in the last four weeks and the other about reasons for absence from training (Zebis et al 2011).

Additional secondary outcomes evaluated at baseline, immediately following and 12 months post intervention include: the degree of neck disability [Neck Disability Index (Vernon 1996)]; health related quality of life [20 item Assessment of Quality of Life Scale, (AQoL instruments 2009, Hawthorne et al 1999)]; physical activity levels [short-form International Physical Activity Questionnaire, (Craig et al 2003)]; self-efficacy to undertake exercise for 20 minutes, three times a week despite various barriers [six questions on a 5-point Likert
scale (Pedersen et al 2013)) and individual stage of change in relation to regular exercise (one question (Marcus et al 1992)).

Consultation with a health professional due to problems in the neck/shoulder region and the number of workers’ compensation claim submitted in the previous 12 months will be evaluated with one question each at baseline and 12 months post-intervention.

The following data will be collected at baseline to control for potential confounding:

- Demographic information including age, gender, body mass index, hand dominance, occupational category, income range, education level, number of comorbidities, medication use for neck symptoms;
- Duration of computer work performed will be evaluated with self-assessment of hours worked per day with a computer;
- Health beliefs will be assessed using three questions from the Fear-Avoidance Beliefs Questionnaire (Hoe et al 2011);
- Three domains of workplace psychosocial factors will be assessed using the 18-item version of the Job Content Questionnaire (JCQ) (Karasek et al 1998, Mausner-Dorsch and Eaton);
- Job Satisfaction will be evaluated with a single item using both words and pictures (faces) (Kunin 1955, Wanous and Hudy 2001, Wanous et al 1997);
- The mental health status of the individual will be recorded with the Kessler 6 scale (Burgess 2007).

**Procedure**

An invitation to participate will be sent from the project coordinator to the workplace liaison for distribution to office personnel. Interested employees will be directed to a project website with information about the research, consent form, as well as questions to determine eligibility and their work location (to establish clusters). The project coordinator will allocate eligible employees to a cluster until the required number (5-8) is reached for each intake. A statistician blinded to the identity of the individuals will assign clusters by simple random allocation to either the control or training group (i.e. individuals will be randomized at the cluster level). A cluster is defined as a small group of people located in the same building, floor or work group. This approach will be used to avoid contamination of the intervention; to enhance compliance with the intervention and to implement the intervention in a natural work
environment. The project coordinator will notify individuals of their allocation after baseline measures have been collected, and communicate between participants and the intervening health professional to organize the ergonomic and exercise assessments. The study will commence in July 2013 with an anticipated final intake of participants in July 2015. The participants receiving and the health professional delivering each intervention cannot be blinded to the intervention group. A second different health professional will be collecting the outcome measures and will be blinded to group allocation.

Data analysis
The data will be analysed on an ‘intent to treat’ basis and per protocol. The effect of the intervention on productivity over the study period will be examined using multi-level generalized linear models. This model will be able to deal with the non-normal nature of the cost data as well as adjust for the effects of clustering as individuals will be nested within each cluster. Secondary outcomes will be analysed by appropriate statistical methods for the type of data. Statistical Models will be developed in consultation with a biostatistician and will adjust for clustering and baseline factors if necessary. We will investigate the distribution of gender and symptoms across the intervention and control groups. In case of uneven distribution, these factors will be included in the model to adjust for their potential confounding effects. Case status will be examined to see whether it modifies the relationship of interest, and if an effect modifier, stratified results will be presented separately. All statistical analyses will be performed using Stata statistical software (StataCorp 2012). An alpha level of 0.05 will be accepted as significant. Missing data will be examined to determine its randomness and addressed with multiple imputations, if required.

Power analysis
A break-even point for the organisation comparing the costs of implementing the program to changes in productivity was used to calculate the sample size. Cost of implementing a 12-week exercise program with one initial assessment was calculated using physiotherapy costs of conducting assessments and exercise programs for Q-Comp (Q-Comp 2011) The cost of time off work to participate in the program (one hour per week) for employees was calculated using the current average office administration wage from Australian data (My Career 2012). Summing the health professional time costs and employee lost time costs, the total cost of the program to the employer was estimated to be $896.80 over 13 weeks. Therefore the
improvement in productivity (changes in absenteeism and presenteeism) needed to be at least $896.80 for the organisation to break-even. Previous Australian research measuring productivity loss due to illness using the HPQ found an average productivity loss per office worker (adjusted to current salaries) from absenteeism and presenteeism of $2,812 (SD $4,133) annually (Hilton et al 2008). Estimated employee numbers based on achieving a $900 difference in means at a power of 80% and a one-sided, alpha error of 0.05 indicated that 262 employees would be needed in each group.

The study design incorporates randomisation of clusters of workers. The extent to which power is diminished by clustering relates to the design effect \( D = 1 + (m - 1) r \) (Cohen 1988), where \( m \) = the average size of a cluster and \( r \) = the intra-class correlation coefficient. Typically, intra-class correlation coefficients are small (< 0.02) (Ukoumunne et al 1999), and we have used a conservatively estimated intra-class correlation of 0.02. A mean cluster size of six is anticipated and based on an ideal number per exercise class, \( D = 1 + (6 - 1) * 0.02 = 1.1 \), thus total sample size required is \((262 * 2 * 1.1) = 576\). With an anticipated loss to follow-up of 10%, the total number of employees to be invited is 640. This sample is similar to other studies using this neck exercise protocol in office workers (Blangsted et al 2008).

**DISCUSSION**

Approximately one in two office workers in Australia is affected by neck pain during their working career. This study is the first to combine evidence-based ergonomic and exercise interventions not only for the prevention of neck symptoms but also for the management of neck pain in office workers. It is also the first to evaluate the impact of an intervention relevant to both the employer (lost productivity) and the worker (perceived neck pain).

This project has several strengths including the innovative design of the interventions with both ‘control’ and exercise training groups receiving similar time with a health professional. The benefit for industry and employees is the comprehensive evaluation of these best-practice interventions that will significantly contribute to informed decision making for the prevention and management of neck pain in the workplace. The simplicity and availability of the interventions to be tested ensure they will have immediate application in industry.
As with any intervention study there is the potential for participants to drop-out or non-attendance for varying reasons. Another limitation is the unpredictability of the economy with organizational restructuring or downsizing a possibility in the current financial climate which may impact recruitment rates. There is also the risk of contamination of interventions with participation of workers from the same organisation allocated to either arm. These limitations will be minimised by strategic recruitment of work groups rather than a whole of organisation.

In conclusion, this trial will impact on physiotherapy practice by offering evidence for the primary and secondary prevention of non-specific neck pain in office personnel. A common concern of industry is that while primary prevention of musculoskeletal problems is a worthy endeavour, little evidence for its potential impact on productivity and health exists. Similarly, the value of interventions to reduce neck pain should not only impact on the individual but also on the organisation’s costs. In other words, interventions recommended and implemented by health professionals are more likely to be implemented and sustained if they offer some financial incentive for the employer to ensure it is a worthy investment.

**Conflict of interest declaration:**

The authors have no conflicts of interest to declare.

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