Jun, Deokhoon, Johnston, Venerina, McPhail, Steven M., & O'Leary, Shaun
(2021)
A Longitudinal Evaluation of Risk Factors and Interactions for the Development of Nonspecific Neck Pain in Office Workers in Two Cultures.
Human Factors, *63*(4), pp. 663-683.

https://doi.org/10.1177/0018720820904231

Title: A longitudinal evaluation of risk factors and interactions for the development of non-specific neck pain in office workers in two cultures

Comprehensive risk factors for neck pain; Original research article. 7540 word counts

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Acknowledgements

Acknowledgments

This research was supported by the Office Ergonomic Research Committee, Minneapolis, MN, USA. The authors wish to thanks the committee for the great support by financing instruments, and participation reimbursement. The research was also supported by Kyungsung University Research grants in 2019 (DJ). SMM is supported

by National Health and Medical Research Council of Australia Fellowship (APP1090440)

Conflict of interest

The authors declare no conflicts of interest.

Abstract

Background: The one year incidence of neck pain in office workers is reported as the highest of all occupations. Identifying risk factors for the development of neck pain in office workers is therefore a priority to direct prevention strategies.

Objective: To identify risk factors for the development of interfering neck pain in office workers including an examination of the interaction effects between potential risk factors.

Methods: Participants included 214 office workers without neck pain from two cultures. A battery of measures evaluating potential individual and workplace risk factors were administered at baseline, and the incidence of interfering neck pain assessed monthly for 12 months. Survival analysis was used to identify relationships between risk factors and the development of interfering neck pain.

Results: One year incidence was 1.93 (95% CI: 1.41 – 2.64) per 100 person months. Factors increasing the risk of developing interfering neck pain were older age, female gender, increased sitting hours, higher job strain, and stress. A neutral thorax sitting posture, greater cervical range of motion and muscle endurance, and higher physical activity were associated with a decreased risk of neck pain. The effects of some risk factors on the development of neck pain were moderated by the workers coping resources.

Conclusion: Multiple risk factors and interactions may explain the development of neck pain in office workers. Therefore, plans for preventing the development of interfering neck pain in office workers should consider multiple individual and work-related factors with some factors being potentially more modifiable than others.

Keywords: Neck pain, office workers, risk factors, interaction effect, incidence

Précis: This study has identified risk factors for the development of neck pain in office workers that supports and enhances a current theoretical framework for neck pain.

Importantly the study also provides evidence of interplay and modifying effects between risk factors.

1. Introduction

Neck pain places a significant burden on both the office worker and industry due to the costs associated with treatment, reduced productivity and work absenteeism (Hansson & Hansson, 2005; M. Pereira et al., 2018; Van Eerd et al., 2011). A key issue with neck pain is that it is a common episodic disorder with a high annual prevalence and incidence among working populations, particularly office workers (Cote et al., 2009). The annual incidence of neck pain in office workers has been reported to be approximately 50% (Hush, Michaleff, Maher, & Refshauge, 2009; Lindegard et al., 2012). Due to its high prevalence and incidence there has been a focus on the identification of risk factors for the development of neck pain in office workers to inform primary and secondary prevention strategies.

Determining risk factors for the development of neck pain in office workers has traditionally been hindered by investigations involving a limited scope of measurements that are often poorly standardized. In response, the Bone and Joint Decade 2000-2010 Task Force (BJDTF) (Cote et al., 2009) has recommended a framework to facilitate comprehensive evidence-based causative modelling to identify risk factors underlying the development of neck pain in working populations. The model proposes two classifications of risk factors, those related to 1) the individual worker, and 2) the workplace. The risk factors related to the individual worker include categories of demographics, ethnicity and country of origin, health behaviours, occupation, general health, and individual psychological factors. The workplace related factors are grouped into psychosocial workplace exposures, physical workplace exposures, and coping with stressors at work. This model has an emphasis on comprehensive risk assessment, hypothesizing that some risk factors may influence the impact of other risk factors on the development of neck pain (Cote et al., 2009). For example, Devereux et al., (2002) demonstrated that workers reported an increased likelihood of neck and upper limb disorders in the presence of both high physical and high psychosocial risk factors, compared to when any one of these risk factors were reported alone. However, these findings were derived from group comparisons (e.g., groups with high physical load and high psychosocial stress versus groups with low physical load and low psychosocial stress) and not by examining the interaction effects on the individual worker level. The BJDTF model also recommends assessing these relationships on an individual level. The model proposes that an individual's characteristics such their coping responses to workplace psychosocial stressors (such as job strain) may potentially modify their level of psychological distress (Choi et al., 2011; Lazarus, 1966; Lian et al., 2016) and its subsequent impact on their development of neck pain. This paper details a prospective longitudinal study that adopted the suggested BJDTF model, evaluating the impact of a comprehensive battery of potential risk factors (individual factors, workplace factors- psychosocial and physical, and coping strategy), including their interaction effects, on the development of neck pain in office workers (Cote et al., 2009).

Psychosocial risk factors are a necessary consideration in the aetiology of neck pain in office workers. Two recent systematic reviews suggest the presence of psychosocial factors may heighten the risk for future onset of neck symptoms based on a number of prospective studies in the working population (Kraatz, Lang, Kraus, Munster, & Ochsmann, 2013; McLean, May, Klaber-Moffett, Sharp, & Gardiner, 2010). A strong association between high job strain and the development of neck pain in office workers has previously been identified (Tornqvist, Hagberg, Hagman, Risberg, & Toomingas, 2009). While psychosocial risk factors appear to be a consistent finding among studies in the field, there is less evidence for physical risk factors that are have been anecdotally implicated in the development of neck pain in office workers (Jun, Zoe, Johnston, & O'Leary, 2017).

Physical risk factors may include workplace (attributes of the workplace environment ergonomic setting and work practices) or individual worker (physical condition and physical behaviours of the worker)(Jun et al., 2017). Few studies have prospectively investigated the impact of physical risk factors on the development of neck pain in office workers. For example, only one workplace factor (close keyboard position <15 cm from the table edge) has been shown in a prospective study to increase the likelihood of a new episode of neck pain (Korhonen et al., 2003). Similarly, the relationship between physical attributes of office workers and the development of neck pain has not been adequately investigated in prospective studies. This is despite aberrant physical function (altered working postures, muscle impairments) having been identified in some office workers with neck pain compared to healthy controls in cross-sectional studies (Szeto, Straker, & Raine, 2002; Szeto, Straker, & O'Sullivan, 2005). In this study, we address this gap by additionally evaluating several potential physical risk factors regarding their impact on the incidence of neck pain. This includes a novel quantitative measure of postural orientation during office work using motion sensors. Our recent study showed these measures to be a reliable method for evaluating postural behaviour in the office work environment (Jun, Johnston, McPhail, & O'Leary, 2019).

The aim of this paper is to describe the prospective study investigating risk factors for the development of neck pain in office workers over a 12 month period. The novel study is a response to the BJDTF recommendations to examine the interaction of a more comprehensive range of potential individual and workplace risk factors, including measures of coping strategies and postural behaviour. It is also distinct from previous studies in that it was conducted in two different cultures. Cultural diversity will feasibly impact workplace culture, beliefs, behaviour, and the emotional health of workers, and subsequently the relationship between work and the development of neck pain. However, previous studies considering the impact of ethnicity and cultural factors on neck pain have focused on immigrant workers within a country, rather than cultural differences between countries (Gerr et al., 2002; Ostergren et al., 2005). South Korea was chosen as a distinctive culture to Australia particularly due to reported differences in aspects of worker health status and work practices. Specifically, a rising prevalence of depression and anxiety disorders has been reported in Korean workers over the last decade (1.8% in 2001 to 2,5%, and 3,1% in 2006 and 2011)(Cho et al., 2015). This higher prevalence of psychological distress in Koreans compared to Australians (prevalence of psychological disorders remained constant between 2001 and 2014)(Harvey et al., 2017) is considered a consequence of the economic situation since the financial crisis of the mid-1990s (Jung, 2013; Kim, Khang, Cho, Chun, & Muntaner, 2011). In addition, Koreans work longer than Australians (1993 and 1665 hours per worker per year in Korea and Australia, respectively according to the OCED data in 2018)(OECD, 2018). Korea also has an authoritarian hierarchical leadership within society (with a high power distance index of 60: indicative of a high power distance society), potentially impacting workplace culture and behaviour of Korean workers, differently to their Australian counterparts (with a low power distance index of 38: less than the world average of 55)(Hofstede, Minkov, & J. Hofstede, 2010). While our primary study hypothesis was that both psychosocial and physical risk factors would be identified for the development of neck pain in office workers (some risk factors modifying the impact of other risk factors), we secondarily hypothesised that some differences in risk factors may be evident between cultures.

2. Methods

2.1. Study Design and sample

A prospective longitudinal cohort study with a 12 month follow-up was performed among office workers from two different cultures, Brisbane, Australia, and Daegu, South Korea. This longitudinal study was nested within the doctoral thesis of the primary author (DJ). Participants were recruited from multiple organizations in both cities through advertisements, social media, word of mouth, and email contact. There were 571 volunteers from six organizations in two regions, Brisbane and Daegu. The majority of volunteers were university educational personnel or faculty members from a University in Brisbane (n= 428) and another university in Daegu (n=81). Other participating organizations included a research centre, management service, industrial-educational agency, and health service institution. All participants provided written consent to participate and ethical approval for the study was granted by the institutional Human Research Ethics Committee (Approval number; 2014000308).

Office workers had to be aged 18 years or older and employed in full time office work (or work more than 30 hours per week) that included computer intensive work for more than 20 hours per week. Participants also had to report an absence of neck pain based on criteria recommended by the BJDTF (Guzman et al., 2008). Specifically, participants had to report no episodes of interfering neck pain, or pain in the shoulder, thorax, or lower back, or other symptoms (ache, tingling, numbness, discomfort) for 1 day or greater during the previous 12 months. Exclusion of participants reporting pain over this broader body region (i.e., shoulders, thorax, lower back) at baseline was applied to minimize selection bias, as the literature suggests that the presence of pain in other body regions may increase the risk of developing neck pain (Cote, Cassidy, & Carroll, 2000; IJzelenberg & Burdorf, 2004). Interfering neck pain was defined as symptoms severe enough to; 1) interfere with daily activities (e.g., disturbed sleep, inability to sustain long periods of reading, computing or driving, reduced social contact, restricted house work) or 2) have taken sick leave or sought health care advice or self-management (e.g., consultation with health professional, self-massage, medication, exercise). As neck pain may occur in childhood (Hogg-Johnson et al., 2008) or and may be recurrent (Bot et al., 2005; Guzman et al., 2008), it was necessary to also exclude office workers reporting any history of significant neck or upper body trauma.

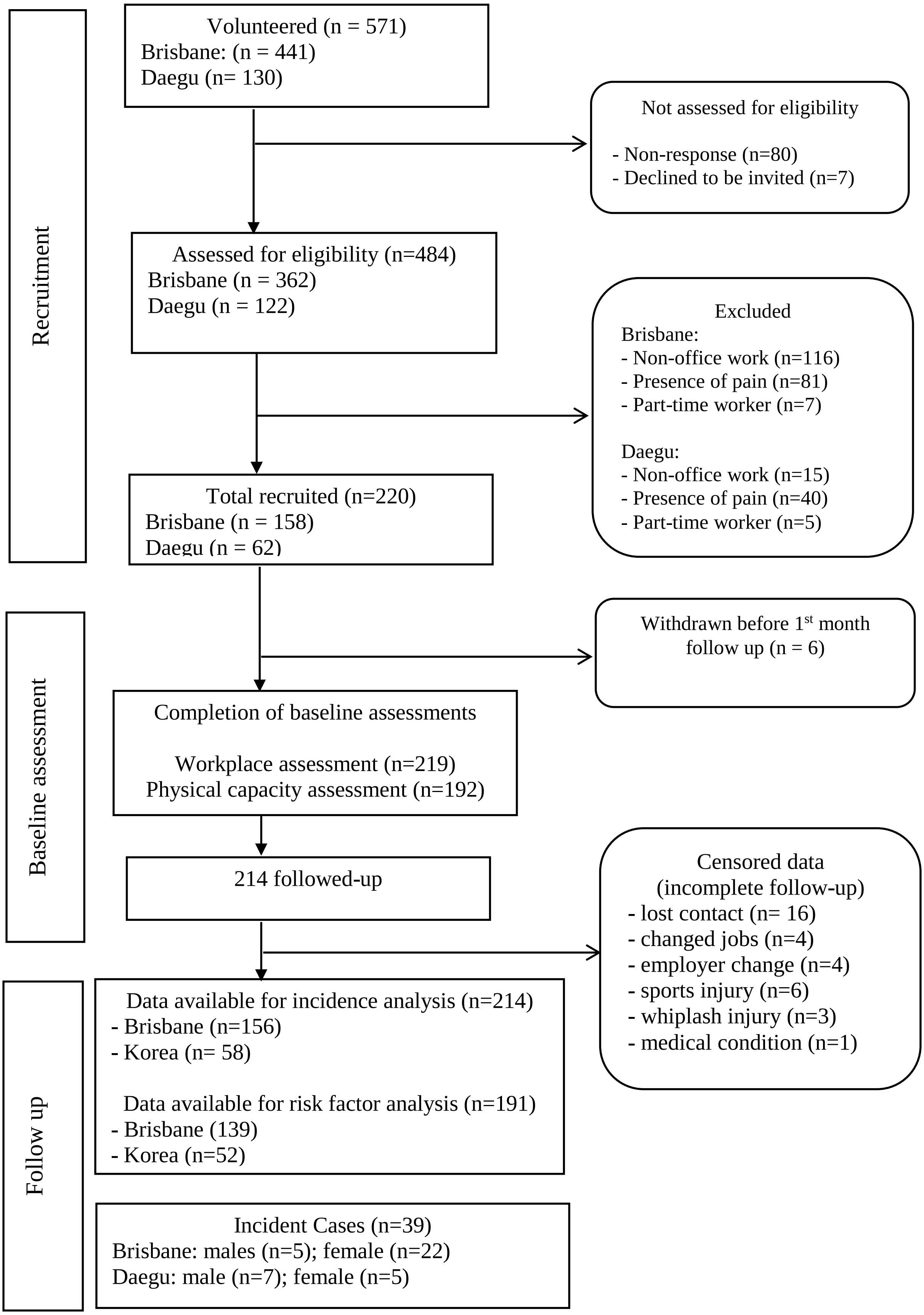

Figure 1. Cohort flow chart

A target sample of 205 was determined based on previous studies (details in Appendix). In total 571 office workers initially volunteered to participate from six organizations in two cities, Brisbane and Daegu. Of these, 87 potential participants did not progress to screening (80 rejected the invitation, 7 did not respond to the invitation). After screening, of the remaining 484 potential participants, 220 satisfied the study criteria (Figure 1).

2.2. Baseline Measurements (Independent Variables)

The baseline measures included were based on the BJDTF framework and those identified in the literature as potentially influential for the development of interfering neck pain. Eligible participants were asked to complete three assessment components. These components included an online survey (section 2.2.1 and 2.2.3), a workplace physical assessment at the participants' workplace (section 2.2.2), and an individual physical capacity assessment at research laboratory (section 2.2.4). Participants completed the online survey at the time of enrolment into the study. The workplace and research laboratory physical assessments were conducted within one week of completing the online survey.

2.2.1. Workplace psychosocial factors

Psychosocial factors were assessed with the Job content questionnaire (JCQ) (R. Karasek, 1985; R. Karasek et al., 1998). A Korean version of the JCQ was utilised for data collection in the Korean participants (Eum et al., 2007). A linear scale for job strain was derived from items assessing psychological demands (5 items related to work overload and time constraints) and decision latitude (9 items related to skill discretion defined by occasions for new learning, task variations and skill development; and decision authority defined by decision allowance, influence on work and policy). The linear scale measure of job strain was derived from equal contributions of these components (by subtraction of decision latitude from psychological job demands) as this has previously been reported to best predict professional status and job characteristics (Landsbergis, Schnall, Warren, Pickering, & Schwartz, 1994). A greater job strain score reflected higher psychological demands and lower levels of decision latitude. Social support in the workplace was evaluated with eight items in the JCQ (four items each relating to support from co-workers and support from supervisors) and combined to create the social support score. Internal consistency indicated by Cronbach's α coefficients for the four scales were acceptable in this study sample (α= 0.70, 0.85, 0.83 and α= 0.70, 0.78, 0.74, for job demand, decision latitude, and job support for Brisbane and

Daegu, respectively. Cronbach's α coefficients for social support in this study sample were 0.83 for Brisbane and 0.74 for Daegu, respectively.

2.2.2. Workplace physical factors

Postural behaviour measure was recorded as the proportion of time (%) participants maintained a pre-defined neutral body posture (recorded with wireless motion sensors) during a 60 minute period of their usual computer work (at their usual office chair and computer workstation in their preferred time). During the testing period sensors continuously recorded the Thorax Angle (TA – sensor 1 attached just inferior to the suprasternal notch, Head Angle (HA - sensor 2 attached to the forehead with a velcro-head band), Arm Angle (AA – sensor 3 attached to the mid-point of the dominant upper arm, and Neck Angle (NA – calculated from the HA and the TA) (Figure 2). Pre-defined neutral body posture ranges for the 4 measured angles were defined from previous literature (McAtamney & Nigel Corlett, 1993; Teschke et al., 2009); neutral TA (between10° extension and 10° flexion), neutral HA (between 5° extension and 10° flexion), neutral NA (between 10° extension and 10° flexion), neutral AA (between 20° extension and 20° flexion). The 60 minute recording duration was based on time restraints imposed by work settings, but also on the findings of our previous study that showed a modest to excellent agreement between these postural behavior measures recorded on separate days (ICC 2.1 ranged 0.70 to 0.84). This later finding indicates the postural behavior measures used in this study provide some representation of routine postural behaviour throughout the day (Jun, Johnston, et al., 2019).

Work practices were measured through a set of questions which included: total working time per week (hours), total working time at computer per day (hours), and normal duration of continuous work prior to a break (hours).

Workplace ergonomic factors were measured using an observational workstation checklist (20-item) (M. J. Pereira, Straker, Comans, & Johnston, 2016). Measurements recorded the size or location of the computer peripherals (chair, desk, keyboard, mouse, computer screen, document) and the worker's body posture relative to the environment (arm supported or not supported posture while using mouse and keyboard) with specific items described in Table A (Appendix).

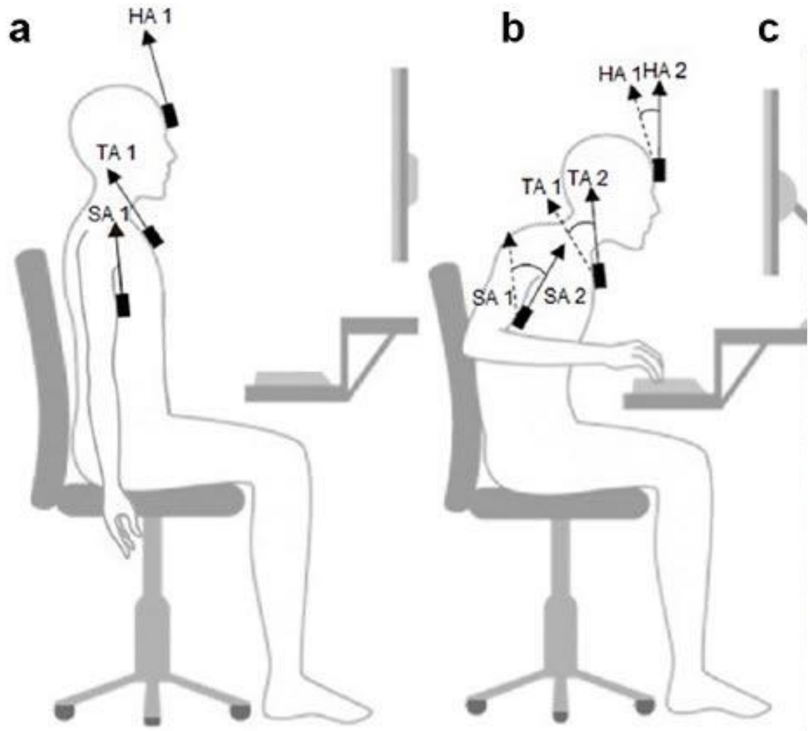

Figure 2. Schematic diagrams showing the reference posture (1a) and an example working posture (1b). Figure 1b demonstrates an example of the changes (relative to the reference posture) in angular displacement of the head (HA1-2 = 15° flexion), thorax (TA1-2 = 20° flexion), shoulder (SA1-2 = 25° extension), and neck, (HA1 − TA1) − (HA2 − TA2) = 5° extension, associated with changes in postural orientation during work. The reference posture was obtained over 5 seconds of recording while sitting quietly in a visually determined upright neutral posture.

2.2.3. Individual psychological factors and coping strategy

Psychological distress was evaluated with the short version of the Depression, Anxiety and Stress Scale (DASS-21) (Lovibond & Lovibond, 2004). A Korean version of the DASS-21 was utilised for data collection in the Korean participants (Jun, Kim, Johnston, & O'Leary, 2018). The three scales each contain seven items to calculate total scores of depression (displeasure, hopelessness, devaluation of life, self-depreciation, lack of interest or involvement, anhedonia, and inertia), anxiety (autonomic arousal, skeletal musculature effects, situational anxiety, subjective anxious affect), and stress (relaxation, nervous arousal, easily upset, irritability, and impatience). This instrument has also shown excellent reliability and validity when administered in clinical and non-clinical populations (Crawford & Henry, 2003), as well as in the Korean translated version used in this study (Jun et al., 2018). The total score of each sub-scale (continuous variables) was used for the analysis. Good internal consistency (Chronbach's α) in this study sample for each scale (Depression, Anxiety, and Stress) was identified at α= 0.82, 0.76, 0.82 and α= 0.85, 0.80, 0.84 for Brisbane and Daegu, respectively (Reynaldo & Santos, 1999).

Individual strategies to cope with workplace stress were measured using the Latack Coping Scale (Latack, 1986) that has been shown to have acceptable validity and reliability (Stephen J. Havlovic & Keenan, 1991). This was included as the BJDTF suggest that coping behaviour might play a role in the development of neck pain in office workers by modifying the impact of other risk factors such as job strain (Cote et al., 2009). A Korean version of the Latack Coping Scale was utilised for data collection in the Korean participants (Jun, Kim, O'Leary, & Johnston, 2019).This scale divides coping into two contrary domains; control coping (positive thinking, direct action, and help seeking) and escape coping (avoidance/resignation and alcohol use) for work stress (Latack, 1986). With acceptable validity and reliability, this is the only current scale for assessing the strategies of coping with workplace stress (Stephen J. Havlovic & Keenan, 1991; S.J. Havlovic & Keenan, 1995). The internal consistency for escape coping and control coping was α= 0.61 and 0.82 for Brisbane and α= 0.70 and 0.87 for Deagu, respectively.

2.2.4. Individual physical factors

The International Physical Activity Questionnaire - Short Form (IPAQ-SF) was used to assess an individual's physical activity level (van Poppel, Chinapaw, Mokkink, van Mechelen, & Terwee, 2010). A Korean version of the IPAQ-SF was utilised for data collection in the Korean participants (Oh, Yang, & Kang, 2007). It consists of four intensity levels: 1) vigorous-intensity activity, 2) moderate-intensity activity, 3) walking, and 4) sitting. The continuous scores derived from three activities except for sitting were chosen in all analyses and defined as a total MET score (total MET = 3.3 X walking minutes X days + 4.0 X moderate activity minutes X days + 8.0 vigorous activity minutes X days). Hours of sitting during week days (work, travel and leisure) was also analysed, which is scored by one item in the IPAQ as a measure of sedentary behaviour of office workers.

Individual Physical Capacity - The order of testing was not randomized but administered from least to most physically demanding to reduce the impact of fatigue on results. While most of these measures have previously established reliability indices, the intra-rater reliability of the investigator conducting the measures was evaluated in 10 office workers with recordings spaced at least one week apart. The reliability coefficients (ICC) for each physical capacity measure is provided in Table B in the Appendix. Physical capacity measures consisted of six individual tests.

1) Active cervical range of motion (degree) in flexion, extension, and axial rotation (left & right), was measured using a Cervical Range of Motion device. The maximal range participants could move with comfort was recorded (Figure A in Appendix) over three repetitions in each direction. For the purposes of analysis cervical right and left rotation values were summed to give an indication of cervical rotation while avoiding the risk of multicollinearity between two similar variables in the model (rotation to left, and rotation to right). This measurement method has established validity and reliability (Audette, Dumas, Cote, & De Serres, 2010).

2) Combined shoulder elevation was conducted to evaluate strength and range of motion of thorax/shoulder region. The distance (cm) arms could be lifted off the supporting surface (elbows extended, thumbs locked, palms downwards) while the body and head were maintained on the surface was recorded over three repetitions (Dennis, Finch, Elliott, & Farhart, 2008). A ruler was used to measure the perpendicular distance from the base of meta-carpal bone of the thumb to the floor (cm) (Figure A in Appendix).

3) Passive shoulder left and right internal/external (shoulder at 90° abduction and elbow at 90° flexion) rotation range of motion was measured using an inclinometer in supine. The

ranges were measured with the participant supine on an examination bed with the glenohumeral joint positioned at 90° abduction (folded towel under elbow to maintain humerus horizontal) and the elbow 90° flexion (Figure A in Appendix). The forearm in vertical represented the 0° starting point (Norkin & White, 2003). Three repetitions of both internal and external shoulder rotation were recorded and the mean value calculated.

4) Isometric cervical flexor and extensor muscle strength (kg) and endurance time (s) (at a load of 50% maximal strength) were measured using a dynamometry with a resistance pad located at the external occipital protuberance for cervical extension tests, and a strap located just above eyebrow level for cervical flexion tests (Figure A in Appendix). After 2 submaximal warm-up trials, three experimental trials of each isometric cervical flexion and extension strength were performed. Participants pushed their forehead against the resistance strap in an intended direction towards the floor in front of them for flexion, and against the resistance pad towards the floor behind them for extension. For endurance measures participants sustained the flexion and extension contractions at a level of 50% of their relevant maximal strength measure as long as they could which was recorded in seconds (time to task failure). Verbal encouragement and visual feedback from a screen display live force as a graph (custom written program by DAQ Factory Runtime, Aveotech, Ashland Oregon) were used to maintain the desired intensity of contraction.

5) Shoulder elevator muscle strength (1-Repetition Maximal (RM) (kg)) and endurance (repetitions (reps) at a load 1kg less than 1-RM) were determined with free weights. Participants performed a lateral arm raise to 90° shoulder abduction in the scapular plane in standing against a wall (L. L. Andersen et al., 2010) (Figure A in Appendix).

6) Progressive Isoinertial Lifting Evaluation (PILE) evaluated dynamic lifting ability. The test has excellent reliability as performed in this study using weights lifted in a plastic box from waist level to shoulder height four times in 20 seconds (Horneij, Holmström, Hemborg, Isberg, & Ekdahl, 2002; Mayer et al., 1988). A sequence of incremental weights was added until the monitored participants' heart rate reached 85% of maximum heart rate or maximum weight lifted safely. The results were expressed as the total work; the sum of force lifted multiplied by the distance between the waist level and shoulder level (kg·m).

2.3. Outcome Variable (Dependent Variable) – Development of interfering neck pain

A new development of interfering neck pain (as defined in eligibility Section 2.1) in the 12 months following the baseline assessment was the outcome for this study consistent with the

BJDTF definition. Cases were identified by a monthly follow-up online questionnaire enquiring about the development of neck symptoms. Participants who answered 'yes' to these questions were also asked to specify the initial date of onset of the episode and the main reason for the occurrence of the episode (e.g., a sports injury, an accident, pregnancy, work-related injury). In the event that the participant nominated a sports injury, an accident, or some other trauma as the cause of their interfering neck pain, the episode was classified as a non-work related interfering neck pain case. In this event follow up of the participant discontinued and their data were not included as an outcome case in the analysis.

2.4. Statistics

Analyses were performed with Stata version 13. Continuous variables were presented as the mean ± SD, and dichotomous or categorical variables were presented numerically or as a percentage. To standardize different units of measurement in some exploratory variables (job strain and escape coping, control coping, social support), z-score transformation was performed for all four explanatory variables. The incidence of interfering neck pain was evaluated by a Survival Analysis approach, where the focus is on the time to the event (development of interfering neck pain) and is adjustable for time variation and drop outs. This time factor was considered important as previous studies show the incidence of neck pain can vary over a follow-up period (Hush et al., 2009; Lindegard et al., 2012; Tornqvist et al., 2009; Wahlstrom, Hagberg, Toomingas, & Wigaeus Tornqvist, 2004). The incidence of a new interfering neck pain case was visualised using Kaplan-Meier survival estimates (Kaplan & Meier, 1958). Potential risk factors for interfering neck pain were examined using Cox Proportional Hazard Analyses with a robust standard errors approach (using Huber-White sandwich variance estimator approach) to adjust for any potential random effects between the two cities (Lin & Wei, 1989). The proportionality of hazard (verification of model assumption) was vetted by means of scaled Scho-enfeld residuals (Cox, 1972). For the highest prediction accuracy with a parsimonious set of independent variables without overfitting each model a least absolute shrinkage and selection operator (lasso) variable selection method was applied instead of step-wise regression (Tibshirani, 1996). Lasso is a technique that overcomes the limitations of OLS regression (prediction accuracy and interpretability) when undertaking variable selection and regularization. The initial model was informed by the variable selection from the lasso method. Demographic factors that were considered to be important covariates (age, gender, and BMI) were included in the model.

To examine the modifying effect of some risk factors on others (as recommended by the BJDTF model), interaction effects between potential risk factors were evaluated by adding interaction terms into the initial model. Specifically, variables that were evaluated for their modifying effects included; coping strategy (Holton, Barry, & Chaney, 2015); social support (Choi et al., 2011; Sanne, Mykletun, Dahl, Moen, & Tell, 2005); muscular strength and endurance (Campbell et al., 2011; Smith, O'Sullivan, Campbell, & Straker, 2010). The newly created model with interaction terms was compared with the initial model, and with possible combinations of interaction term subsets using the Akaike's information criterion (AIC) (Akaike, 1974). The most parsimonious model identified from this approach was considered the final model. Predictive power of the fitted models were also examined using Harrell's concordance statistic (goodness of fit of model) with 0.5 indicating no discrimination and 1.0 indicating perfect prediction (Harrell, Lee, & Mark, 1996; Newson, 2010), with the same final model having the greatest predictive power. When an interaction effect was identified, it was measured by plotting the change of marginal effect of each risk factor on the development of interfering neck pain (Brambor, Clark, & Golder, 2006).

Table 1. Distribution of risk factors included in the survival analysis in Brisbane and Daegu.

Variables	Brisbane (n=156)	SD / %	Daegu (n=58)	SD / %	Total (n=214)	SD / %
Age (years)	37.4	±9.9	37.2	±10.0	37.3	±9.9
Female (n/%) *	94	60.3%	24	41.4%	118	55.1%
BMI (kg^2/m) *	24.5	±4.4	22.6	±3.5	24.0	±4.2
Hours of sitting during week days work and home (hrs)	52.7	±11.1	49.5	±13.3	51.9	±11.8
Physical activity (total MET)*	2728.9	±1949.7	2018.0	±1756.8	2536.3	±1921.6
Job strain *	-19.7	±6.2	-16.6	±3.2	-18.9	±5.7
Social support *	25.3	±3.3	24.0	±2.4	24.9	±3.1
Control coping *	63.2	±8.4	59.7	±9.5	62.3	±8.9
Escape coping	19.7	±4.1	19.2	±4.5	19.6	±4.2
Stress symptom	4.5	±3.4	5.2	±3.1	4.7	±4.2
Mouse located in front of and close to the body (n)						
Yes	109	69.9%	40	69.0%	149	69.6%
No	47	30.1%	18	31.0%	65	30.4%
Cervical flexor endurance time (s)†	37.2	±15.5	35.5	±15.0	36.7	±15.4
Cervical extensor endurance time (s)†	91.2	±73.3	104.8	±80.2	94.9	±75.2
Neutral thorax posture (%)*	51.8	±34.1	24.4	±23.8	44.3	±33.8
Neutral head posture (%)*	53.4	±24.6	39.9	±21.9	49.5	±24.7

Neutral arm posture (%)*	38.8	±33.4	19.4	±21.7	33.5	±31.8
Neutral neck posture (%)*	52.8	±23.7	39.5	±20.7	49.2	±23.6
Active cervical extension ROM (°)*†	72.8	±12.2	82.8	±11.0	75.5	±12.6
Passive shoulder rotation ROM (°)*†	139.9	±14.7	126	±17.0	136.2	±16.5

*: $p<0.05$ for 2x2 chi square test $\chi 2$ (dummy variables), Fisher exact test (categorical variables) or t-test (continuous variables) of the comparisons between Brisbane and Daegu regions. †: the variables only included 192 office workers from Brisbane (n=140) and Daegu (n=52). ROM: range of motion, kg: kilogram, m: meter, hrs: hours, MET: Metabolic equivalent minutes s: second. Neutral postures were defined as the angular range between 10° extension and 10° flexion for thorax, between 5° extension and 10° flexion for head, between 10° extension and 10° flexion for neck, and between 20° extension and 20° flexion for arm. The range of raw scores (before z-score transformation) for job strain, social support, control coping, escape coping, and stress symptom in the study population were -37 to -1, 15 to 32, 29 to 84, 8 to 33, and 0 to 20, respectively.

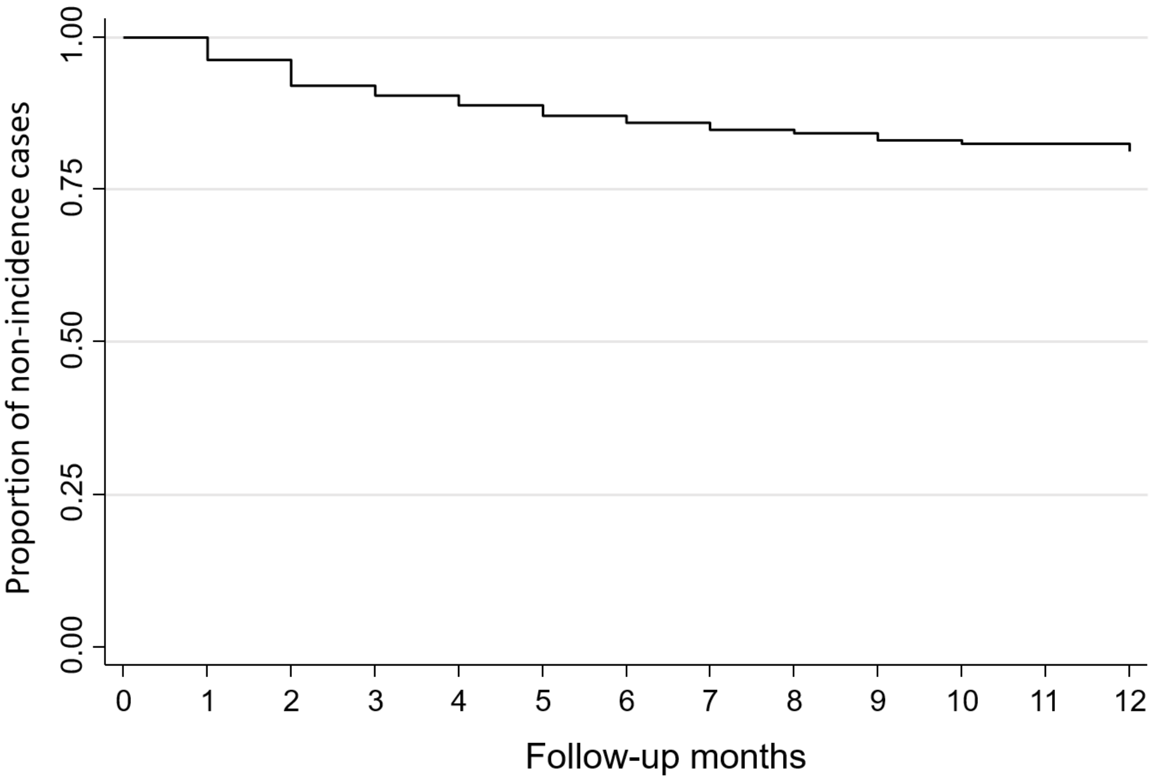

Figure 3. Kaplan-Meier survival curves for the incidence of interfering neck pain during the 12 month follow-up. The Y-axis indicates the percent of participants each month of the follow up period who did not report a development of interfering neck pain.

3. Results

3.1. Baseline and follow-up characteristics

Of the 220 participants, data from 214 participants were included in the incidence analysis, and data from 191 participants included in the final risk factor analysis. Contact was lost with six participants prior to their first month follow-up outcome measurement (four of these participants also did not complete their physical capacity assessment). Therefore, the Kaplan-Meier incidence estimate with censored data sample was performed with 214 participants, after excluding these six participants. Twenty-nine workers only partly completed either the workplace postural assessment or the physical capacity assessment due to time constraints, and declined to participate in both assessments. Therefore, the survival analysis was performed with data from 191 participants who completed both assessments. The drop-out rate was 11.2% for the total 12 month duration (n= 24/214). Data collected prior to the participant dropping out of the study was retained for the survival analysis. Data were also censored before the 12 month follow up if participants reported a sports injury (n=6), whiplash injury (n=3), or medical condition (n=1) as the cause of their incident of interfering neck pain. Descriptive details of the 191 participants included in the final analysis (including risk factor differences between cultures) are shown in Table 1. Independent variables examined in the initial analysis but not included in the final model are shown in Table C in the Appendix. Findings from participants with missing data (n=29) did not differ from those of participants with completed data (n=191) for any of the baseline variables ($p>0.05$ for T-test or Fisher exact test).

3.2. Incidence

The incidence rate (95% CI) of interfering neck pain observed in this study was 1.93 (1.41 to 2.64) per 100 person months (Figure 3). Most participants (81.8%) did not develop a new incidence of interfering neck pain with a total cumulative incidence of 39/214 (18.2%) new cases observed. A difference was found between male (12 cases) and female workers (27 cases) in the equality of survivor proportion (Log-rank test; $p=0.051$). No significant difference in incidence was found between the cities of work (Brisbane, Daegu).

3.3. Risk factors for the onset of interfering neck pain in office workers.

The lasso variable selection method identified 12 risk factors associated with the development of interfering neck pain (exclusion of three covariates age, gender, and BMI).

Univariate and multivariate association between risk factors and the development of interfering neck pain are shown in Table 2. The best fit multivariate model with three interaction effects was included in the final model (least AIC value and highest prediction). In the case where risk factors were moderated by other risk interactions, interaction graphs were developed (Figures 4-6) illustrating the linear relationship between the predictor variables and the development of interfering neck pain, relative to the magnitude of the moderating variables.

Table 2. Univariate and Multivariate Cox Proportional Hazard models showing the calculated Hazard Ratio and significant interactions for risk factors and development of interfering neck pain in office workers (n=191)

Risk factors	Univariate HR	*p*	95% CI	Adjusted HR	*p*	95% CI
Age (decades)	1.05	0.79	0.75 – 1.46	**1.25**	**<0.001**	**1.21 – 1.29**
Gender						
Male	**Reference**			**Reference**		
Female	**2.42**	**<0.001**	**1.64 – 3.56**	**1.94**	**<0.001**	**1.38 – 2.73**
BMI (kg/m2)	1.00	0.96	0.99 – 1.01	0.98	0.74	0.87 – 1.10
Physical activity (total MET)	**0.74**	**<0.001**	**0.70 – 0.78**	**0.72**	**<0.01**	**0.90 – 0.87**
Hours of sitting during week days at work and home (hrs)	1.01	0.10	1.00 – 1.03	**1.04**	**<0.001**	**1.03 – 1.06**
Cervical flexor endurance time (sec)	1.00	0.98	0.99 – 1.01	**1.06**	**0.03**	**1.01 – 1.12**
Cervical extensor endurance time (sec)	**0.99**	**<0.001**	**0.99 – 0.99**	**0.98**	**<0.001**	**0.98 – 0.99**
Mouse location						
located in front of and close to the body	**Reference**			**Reference**		
located away from body	**1.61**	**<0.01**	**1.17 – 2.22**	1.86	0.12	0.85 – 4.05
Neutral thorax posture (% time)	**0.99**	**<0.001**	**0.98 – 0.99**	**1.02**	**<0.001**	**1.02 – 1.02**
Active cervical extension ROM (°)	0.99	0.11	0.98 – 1.00	**0.98**	**<0.001**	**0.97 – 0.99**
Job strain (z-score*)	1.00	0.99	0.84 – 1.19	**0.64**	**<0.001**	**0.57 – 0.71**
Social support (z-score†)	1.28	0.52	0.59 – 2.77	**1.86**	**0.03**	**1.07 – 3.23**

Escape coping (z-score†)	**1.51**	**<0.01**	**1.14 – 2.01**	1.57	0.24	0.74 – 3.30
Control coping (z-score†)	**0.79**	**0.02**	**0.65 – 0.96**	**0.60**	**<0.01**	**0.42 – 0.75**
Stress symptom (z-score†)	**1.52**	**<0.01**	**1.15 – 2.02**	**1.96**	**0.02**	**1.13 – 3.38**
Job strain X Control coping (interaction)				**0.68**	**<0.001**	**0.62 – 0.73**
Stress X Social support (interaction)				**0.74**	**<0.001**	**0.70 – 0.78**
Neutral thorax posture X Cervical flexor muscle endurance time (interaction)				**0.99**	**<0.001**	**0.99 – 0.99**
Harrell's C index			.83 (95% Confidence Interval .75 – .91)			

HR: Hazard ratio, CI: Confidence Intervals, Hazard ratios in bold indicate p<.05. ROM: range of motion, kg: kilogram, m: meter, hrs: hours, MET: Metabolic equivalent minutes s: second. *higher z-score for job strain indicates less job strain on workers due to the negative value of the raw score. †higher z-score indicates higher score of each factor. The hazard ratio of risk factors where interaction analysis was applied only indicates the hazard ratio on the development of interfering neck pain when the moderator effect is zero (e.g., hazard ratio of job strain is 0.64 when control coping is absent) (Brambor et al., 2006). Thus, the interpretation for the average of the hazard ratio should be done on the graphs where specific levels of moderators are present.

Factors increasing the risk of the development of interfering neck pain

Older age, female gender, increased sitting hours during week days (work and home), higher levels of job strain and psychological stress, were associated with increased risk of interfering neck pain (risk estimates in Table 2). Higher control coping and social support were found to have a moderating effect buffering the adverse impact of job strain and psychological stress on the development of interfering neck pain, respectively (Figures 4 and 5). Specifically, the calculated statistical coefficient for job strain for the development of interfering neck pain was 0.63 (Table 2). However, this only indicates the regression coefficient of job strain when the control coping score is at its minimum (represented as absent in the model) (Brambor et al., 2006). Instead, the relationship between job strain, control coping, and the development of interfering neck pain can be more clearly visualised and interpreted in Figure 4, which permits the relationship between job strain and the development of interfering neck pain to be judged at different levels of control coping. This interpretation also applies to the relationship between other predictor variables as depicted in Figures 5 and 6.

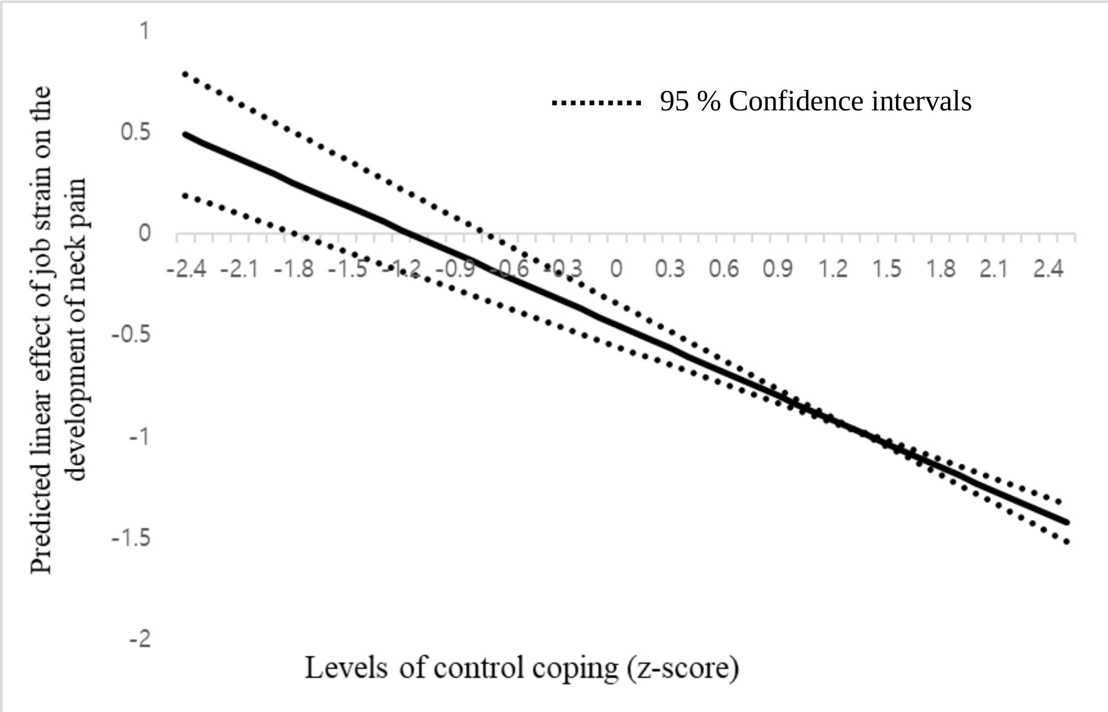

Figure 4. The marginal modifying effect of control coping on the relationship between job strain and the development of interfering neck pain in office workers. The solid line indicates reduced adverse effects of job strain on the development of interfering neck pain as the levels of control coping increase.

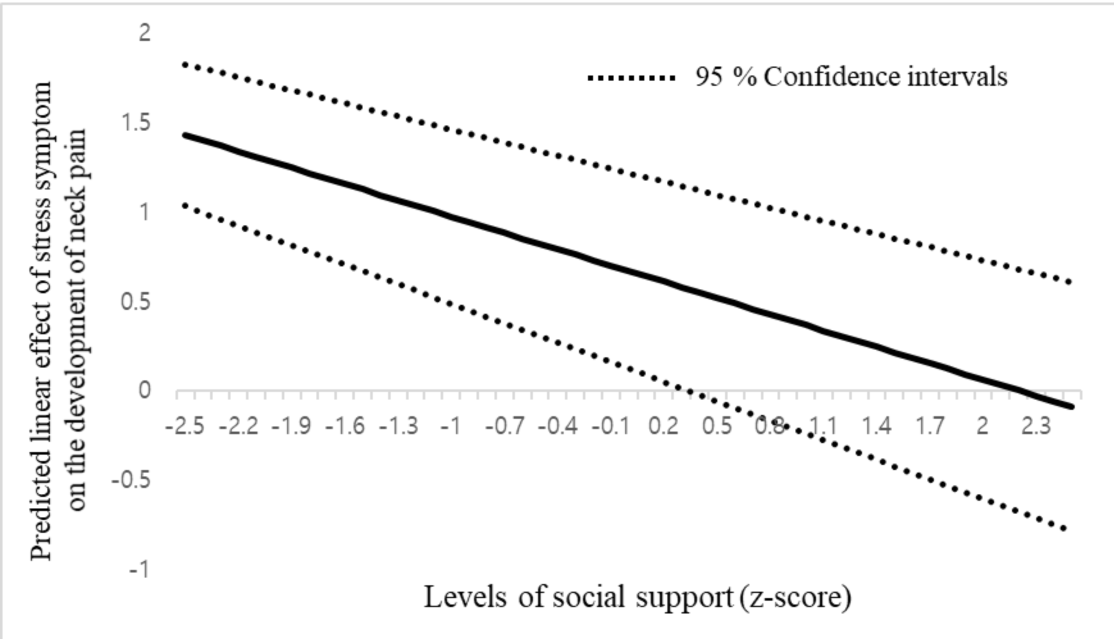

Figure 5. The marginal modifying effect of social support on the relationship between stress symptom and the development of interfering neck pain in office workers. The solid line indicates reduced adverse effects of stress symptom on the development of interfering neck pain as the levels of social support increase.

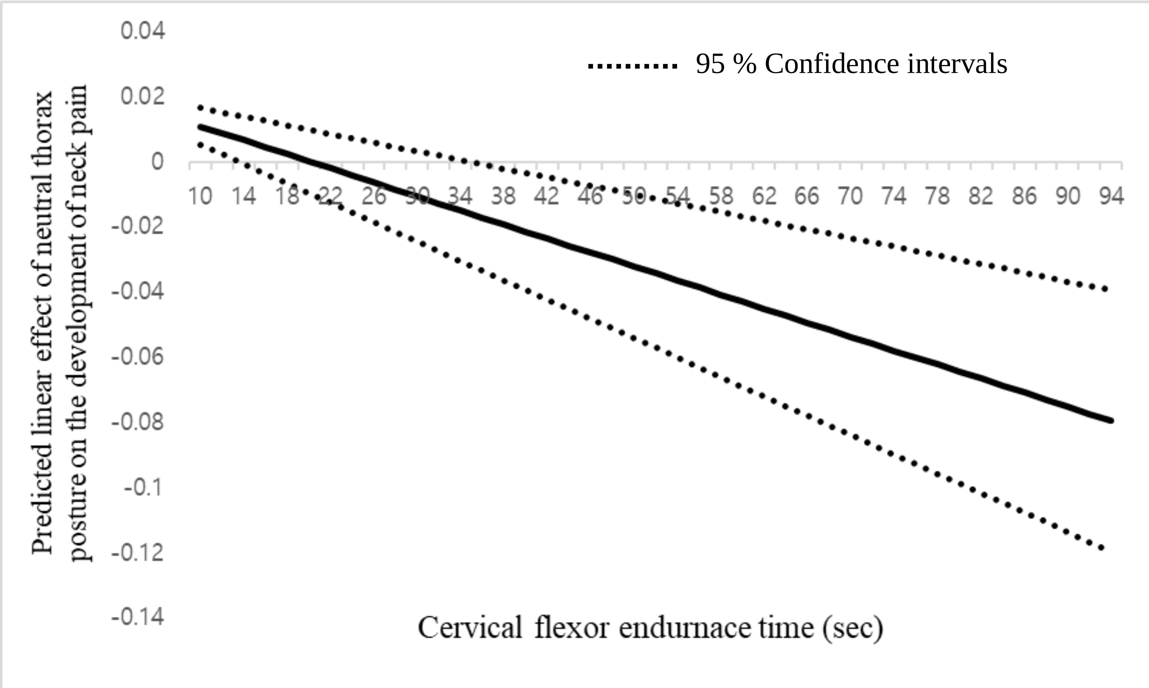

Figure 6. The marginal modifying effect of cervical flexor endurance time on the relationship between neutral thorax endurance time and the development of interfering neck pain in office workers. The solid line indicates the beneficial effects of neutral thorax posture on the development of interfering neck pain is prominent as the levels of cervical flexor endurance time increase.

Factors associated with a decreased risk of the development of interfering neck pain

An increased percent of time working in a neutral thorax posture, greater endurance of the cervical extensor muscles, greater cervical extension range of motion, and higher levels of physical activity were all associated with decreased risk of interfering neck pain (risk estimates in Table 2). The beneficial effect of greater time in a neutral thorax posture on the development of interfering neck pain was significant only with greater recorded endurance time of the cervical flexor muscles (>35 sec endurance time) (Figure 6).

4. Discussion

Study findings support the hypothesis that both psychosocial (e.g., higher levels of job strain and psychological stress) and physical traits (e.g., postural behaviour, sitting time) may play a role in the development of interfering neck pain in office workers, with some factors (e.g., coping resources, social support) modify the impact of others. While the proportion of new interfering neck pain did not differ between cultures, some differences in the recorded magnitude of potential risk factors were evident between cultures (e.g., work practices, desk setting, and individual physical behaviours. see Table 1) supporting our second study hypothesis. However, the findings in the final model were not impacted by adjustment for these cultural differences in the magnitude of some risk factors. Therefore, the risk factors identified are able to be generalised to both cultures studied.

Older age and female gender were risk factors for developing interfering neck pain in office workers (Kraatz et al., 2013; Linton, 2000; McLean et al., 2010). In the workplace, both psychosocial and physical factors were found to increase, or decrease, the risk of developing interfering neck pain. Longer sitting hours during the work week were found to increase the risk of developing interfering neck pain in office workers that was not impacted by interaction effects of other risk factors. The survival analysis showed that for each additional hour of sitting during week days there was a 4% higher risk of developing a new episode of neck pain (HR 1.04). Previous cross-sectional studies have reported positive relationships between work sitting time and neck-shoulder pain severity in working populations (Cagnie, Danneels, Van Tiggelen, De Loose, & Cambier, 2007; D. M. Hallman, Gupta, Mathiassen, & Holtermann, 2015; Skov, Borg, & Orhede, 1996; Yue, Liu, & Li, 2012). This is the first longitudinal study, however, to show longer sitting time during the working week to increase the incidence of neck pain in office workers (Jun et al., 2017). In fact, in some groups of occupations such as blue collar workers, increased sitting time at work may reduce the risk of neck problems by lessening the exposure to other bio-mechanical risks (for example, heavy manual work) (David M. Hallman et al., 2016). Furthermore, it should also be acknowledged that the measure of sitting time in this study while related to total sitting hours during the working week, also included sitting hours outside of work recorded by self-report, rather than objectively measured.

Factors inferring a better level of physical condition (cervical extensor endurance, and cervical extension range of motion) and physical activity levels (total MET from IPAQ) were the only variables directly associated with a decreased incidence of interfering neck pain that were not moderated by other variables. These findings are consistent with biomechanical studies that show the dependence of the cervical vertebral column on the physical support of muscles (Panjabi et al., 1998), mechanistic studies showing the presence of impaired muscle function (including the extensor muscles) in neck pain (Falla, Jull, & Hodges, 2004; O'Leary, Cagnie, Reeve, Jull, & Elliott, 2011; Oliveira & Silva, 2016; Schomacher & Falla, 2013), and clinical trials showing cervical muscle training to be effective in reducing neck pain (Blangsted, Sogaard, Hansen, Hannerz, & Sjogaard, 2008; Falla, Jull, Hodges, & Vicenzino, 2006; Falla, Jull, Russell, Vicenzino, & Hodges, 2007; Sihawong, Janwantanakul, & Jiamjarasrangsi, 2014).

Increased physical activity and less time sitting were found as having a beneficial effect on reducing the development of interfering neck pain. A previous longitudinal study specific to asymptomatic office workers found that for every 1,000 steps of walking, the risk of neck pain reduced by 14% (OR 0.86 CI 0.74–1.00) (Sitthipornvorakul, Janwantanakul, & Lohsoonthorn, 2015). The benefit of physical activity for management of musculoskeletal pain (including neck pain) and mental health outcomes has been reported (Geneen et al., 2017; Herring, O'Connor, & Dishman, 2010; Rethorst, Wipfli, & Landers, 2009). These physical behaviours (less sitting and more physical activity) may appear to match the general advice and benefits of regular exercise for improving health outcomes.

Office workers who spent a greater proportion of their recorded time working in a neutral thorax sitting posture were also less likely to experience new development of interfering neck pain. These findings are consistent with clinical recommendations for regular attainment of a more neutral sitting working posture (Caneiro et al., 2010; Stephen J. Edmondston et al., 2007; S. J. Edmondston, Sharp, Symes, Alhabib, & Allison, 2011; Falla et al., 2007). Deviation from a neutral sitting posture (e.g. forward head postures) has been associated with altered spinal muscle activity (S. J. Edmondston et al., 2011; Schuldt, Ekholm, Harms-Ringdahl, Nemeth, & Arborelius, 1986; Bahar Shahidi, Haight, & Maluf, 2013) as well as neck motion (Aaras, Horgen, Bjorset, Ro, & Thoresen, 1998; S. J. Edmondston et al., 2011; Yip, Chiu, & Poon, 2008) with proposed potential for neck strain (Straker, Skoss, Burnett, & Burgess-Limerick, 2009; Yip et al., 2008). However, these inferences based on the findings from this current study are speculative as measures of muscle activity (such as electromyography) were not recorded concurrently with the measure of postural behaviour. A salient finding from this current study, however, is the impact of the thorax posture measure. Previous studies have mostly focused on the association between head / neck posture and neck pain in office workers (Marcus et al., 2002; B. Shahidi, Curran-Everett, & Maluf, 2015). This study suggests that thorax posture (the thorax providing carriage of the cervical spine and head, thus impacting their orientation) may be a relevant postural behaviour measure to capture when investigating the genesis of neck pain. The moderating effect of cervical flexor muscle endurance on the relationship between neutral thorax posture and the development of neck pain (Figure 6) does support the functional link between the thorax and cervical spine, and the relationship and benefits of good postural behaviour and muscular health in minimizing neck pain. The role of the cervical flexor muscles in physically supporting the cervical spine (including postural orientation) has been previously noted (Kettler, Hartwig, Schultheiss, Claes, & Wilke, 2002; Mayoux-Benhamou et al., 1994). Collectively this apparent importance regarding increased cervical extensor (reducing the incidence of neck pain) and flexor (assisting neutral posture) muscle endurance in physically supporting and protecting the cervical column from painful strain is consistent with their synergistic postural role (Jull, Sterling, Falla, Treleaven, & O'Leary, 2008).

Findings also support previous research suggesting that psychosocial factors such as job strain and psychological stress increase the risk of developing neck pain in office workers (Kraatz et al., 2013). The findings of this study also showed that the interaction of these risk factors and the development of neck pain seem to be moderated by the worker’s coping resources (e.g., coping strategy, social support), as was inferred in the BJDTF (Cote et al., 2009) model. Specifically, when workers used lower levels of control coping, greater adverse effects of job strain on the development of neck pain were reported (Figure 4). Social support was also found as another moderating factor that reduced the positive association between psychological stress and risk of developing neck pain. This buffering effect of social support on stress-health models has previously been reported in the literature (Choi et al., 2011; R. A. Karasek, Triantis, & Chaudhry, 1982; Sanne et al., 2005). From a psychosocial perspective the results of this study suggest that individual cognition and coping style in response to workplace stressors, and the level of support from colleagues and supervisors may influence or modify the relationship between these stressors and the development of neck pain in office workers.

Some variables previously reported as risk factors for the development of neck pain in office workers, such as ergonomic factors and the amount of VDT work, weren’t identified as risk factors in this study. There were minor differences between the two countries with workers in Korea reporting slightly longer hours of work than those in Australia, but the time spent performing computer work did not differ (See Appendix). Potentially the influence of relative variables such as postural behaviour (e.g., neutral thorax posture) may have negated the impact of some ergonomic factors on the development of interfering neck pain in the analysis model. This is particularly so given the reported impact of some ergonomic factors (e.g., desk height, keyboard-body distance) on postural orientation of the spine (Kotani, Barrero, Lee, & Dennerlein, 2007; Queensland Department of Justice and Attorney-General, 2012; Saarni, Nygård, Kaukiainen, & Rimpelä, 2007; Zacharkow, 1988). In the current study a greater proportion of Korean participants used forearm supported strategies, had significantly higher desks, and a greater keyboard-desk edge distance, compared to the Australian participants (See Appendix). These ergonomic differences may at least in part explain the observed postural behaviour differences between countries. Therefore, while ergonomic variables were not identified as a risk factor for neck pain in this study, clinicians should still consider their potential impact on an individual's work practices when devising preventative strategies. Similarly, muscle strength and lifting function variables were not shown to be risk factors for the development of neck pain in office workers in this study. Deficits in neck and shoulder muscle strength are a known feature in some neck pain presentations (Rezasoltani, Ali-Reza, Khosro, & Abbass, 2010; Ylinen, Salo, Nykänen, Kautiainen, & Häkkinen, 2004) and training that have included elements of strengthening have been shown to reduce neck pain (C. H. Andersen, Andersen, Zebis, & Sjogaard, 2014; L. L. Andersen et al., 2011; Sihawong et al., 2014). However, it is difficult to be conclusive regarding the causal relationship between different elements of muscle performance (i.e., strength versus endurance) and the development of neck pain from the current and previous studies (Hamalainen, Vanharanta, & Bloigu, 1994; Hamberg-van Reenen et al., 2006; Hamberg-van Reenen, Ariens, Blatter, van Mechelen, & Bongers, 2007). At this stage the collective findings of the current and previous studies infer that good physical health of the cervical musculature (as indicated by the findings for cervical extensor and flexor endurance measures in this study) is an important component (together with the other identified risk factors) for the prevention of neck pain in office workers.

The cumulative incidence of interfering neck pain in this study (18.2%), is lower than the 34 to 49% incidence rates of neck pain in office workers reported in several studies that used a variety of different neck pain case definitions (intensity, duration, or functional limitation), hampering direct comparisons (Jun et al., 2017). We used monthly report to minimize recall bias and strict case definition (ie interfering neck pain) to avoid ambiguity, where neck pain was problematic enough to interfere with function, taken sick leave or sought health care advice or self-management. Interestingly there appeared to be a higher incidence of neck pain early in the 12 month follow up period than in the mid-late follow up period (figure 3). While the reason for this is unclear this observation is consistent with findings in previous studies (Hush et al., 2009; Lindegard et al., 2012; Tornqvist et al., 2009; Wahlstrom et al., 2004) and potentially reflects heightened awareness of neck symptoms in participants from their recent onset of participation in the study, although this is speculative. Although some risk factors appeared to be higher in the Korean workers, the incidence of developing interfering neck pain did not differ between cultures in this study cohort. Korean culture (as is similar in other Asian countries) tends to be more collectivist and hierarchical than Western cultures with typically longer hours of work (Lee, 2012). Participants from Daegu worked longer hours, had higher levels of job strain and less physical activity than their Australian counterparts, which may have explained the higher depression and anxiety symptoms. However, the incidence findings suggest that these cultural differences do not influence the risk of developing interfering neck pain in office workers. The findings of this study are therefore likely to be generalizable across these cultures. It is acknowledged however, that only two cultures were included in the present study and future studies conducted across multiple cultures will better indicate the extent to which these findings are generalizable beyond cultures with similar characteristics to those represented in the present sample.

4.1 Implications for office workers and employers

The findings of this study have practical implications for prevention strategies for interfering neck pain in office workers. Many of the risk factors are potentially modifiable factors such as job strain, coping strategies, physical activity levels (time spent sitting and walking), sitting postural behaviour, and cervical muscle endurance. The findings of this study suggest that multiple factors may need to be considered including workplace and individual factors to address the prevention of interfering neck pain in office workers. The study also supports the notion of the Bone and Joint Decade 2000-2010 Task Force that the effect of risk factors may be moderated by other risk factors. This is important from a practical perspective. For example, it may be intuitive to initially address factors associated with higher job strain (i.e., psychological demands and decision latitude) in an attempt to reduce the risk of interfering neck pain in the office setting, however this may require changes at the organisational level.

Instead an alternative pathway may be to target factors relatively easier to modify such as the worker's coping strategies and social support in the workplace. Therefore, knowledge and education regarding the potential impact of the relationship between coping and stress-health mechanisms may be informative in designing programs to prevention of interfering neck pain in office workers. The new findings of this study may suggest a revision of the current BJDTF model that is specific to office workers and interfering neck pain (figure 7). Social support may play an important role as "coping with stress at work" in BJDTF etiological diagram in modifying the risk of individual stress levels. Thus, the dashed oval labelled "coping with stress at work" can be better described by labelled "coping with stress at work and social support". To note that the other observed modifying effects are adequately described in the original diagram.

4.2. Strengths and Limitations

This is one of the few prospective studies to investigate a comprehensive set of risk factors for the development of neck pain (B. Shahidi et al., 2015). Methodological strengths included an objective measure of postural behaviour at work, frequent outcome assessments, application of moderating factors, and consideration of cultural variation. There are also limitations of the study. The outcome assessment and some risk factors were measured using self-report with the possibility of over or under-reporting of neck cases and risks. Postural behaviour measures were only recorded on one occasion and therefore may not be entirely representative of the participants' overall postural behaviour. While our previous study did indicate these postural behaviour measures have acceptable reliability over separate days and time periods, a greater number of sampling time-points or sampling for longer periods in future study may further reduce the risk of sampling error or reactivity to monitoring (Liv, Mathiassen, & Svendsen, 2012). Time-dependent risk factors were also not measured on multiple occasions such as stress levels, ergonomic setting, sitting time and job strain that may have varied over time. However, the analysis of this study hypothesis relied on the fixed variable values assessed at the baseline. Subsequent studies will need to consider the potential changes in the status of these risk factors over time and their relationship with the development of neck pain. Lifestyle factors outside of work (such as smartphone use or other recreational activities) were not evaluated as the intent was to target work related factors in the present study. It was also beyond the scope of the present study to include an extensive gamut of non-workplace factors, which would have required a much larger sample size.

Although this study identified moderating effects of coping resources on risk factors for the development of neck pain, other interactive relationships with other risk factors are still unclear. In addition, the worker's coping strategy assessed in this study included only workplace stressors. Future studies could consider the role of the individual's cognitive and general coping strategies to life stressors which may further identify relationships between risk factors and the development of neck pain.

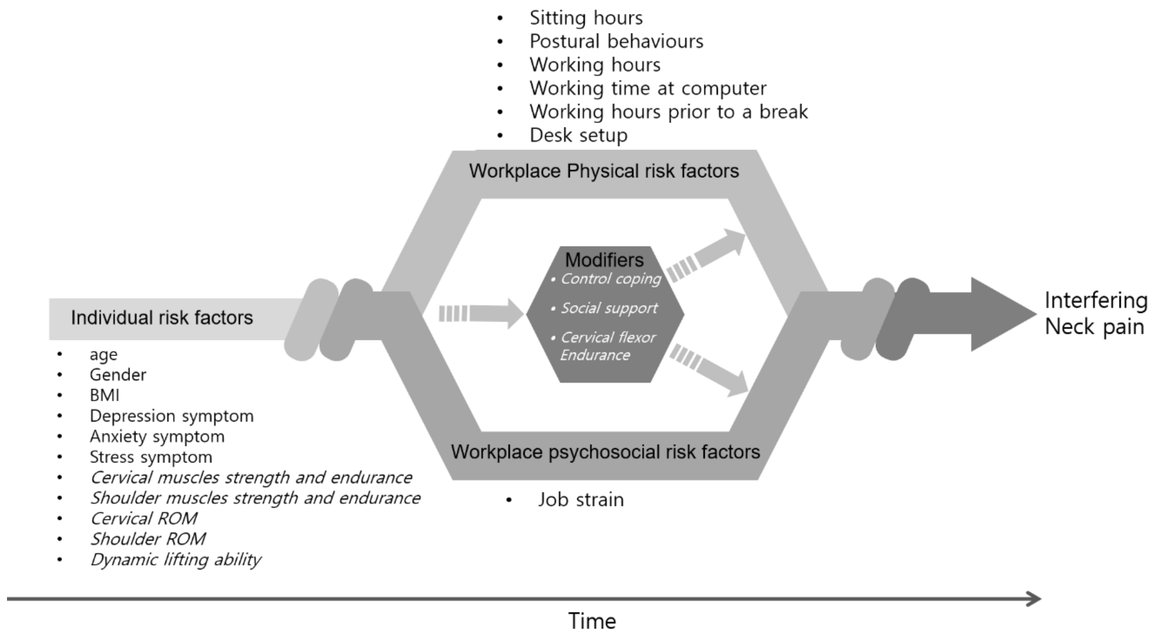

Figure 7. A simplified etiological model for interfering neck pain in office workers as adapted from the BJDTF etiological diagram (Cote et al., 2009). The line forming the outer hexagon represents the associations between risk factors resulting in the development of interfering neck pain. The inside hexagon and dashed arrows represent the modifying effect of coping with stress at work, social support, and cervical flexor muscle endurance, between risk factors and developing interfering neck pain. The risk factors in italic font are the factors associated with a decreased risk of the development of interfering neck pain.

5. Conclusion

The finding of this study supports the role of individual, physical, and psychosocial risk factors independently and in combination on the development of interfering neck pain in office workers. Both physical factors such as physical activity level, posture and muscle conditioning, as well as psychosocial factors such as job strain and psychological stress potentially alter the risk of office workers developing interfering neck pain. General features such as older age and female gender may threaten office workers` neck health. The impact of these risk factors however, may be modified by other attributes of the worker and the workplace. Therefore, prevention planning for interfering neck pain in office workers should consider multiple individual and work-related psychosocial and physical risk factors with some factors being potentially more modifiable than others.

Key points

- Findings have informed a current theoretical framework for interfering neck pain specific to office workers generalizable to two distinctive cultures.
- Measurement of postural behavior captured by wearable motion sensors may be able to identify a higher risk of an office worker developing interfering neck pain.
- Prevention planning for interfering neck pain in office work needs to consider multiple potentially modifiable biopsychosocial influences that include factors relevant to the workplace and the individual worker.

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