A Path Analysis of the Effects of Biopsychosocial Factors on the Onset of Nonspecific Low Back Pain in Office Workers

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Abstract

Objective: The purpose of this study was to develop a conceptual model for the association between various biopsychosocial factors and nonspecific low back pain (LBP) in a sample of office workers.

Methods: A 1-year prospective cohort study of 669 healthy office workers was conducted. At baseline, a self-administered questionnaire and standardized physical examination were employed to gather biopsychosocial data. Follow-up data were collected every month for the incidence of LBP. A regression model was built to analyze factors predicting the onset of LBP. Path analysis was performed to examine direct and indirect associations between identified risk factors and LBP.

Results: The onset of LBP was predicted by history of LBP, frequency of rest breaks, and psychological demand, measured by the Job Content Questionnaire. All 3 factors directly related to LBP; history of LBP was the strongest effector on the onset of LBP. History of LBP and frequency of rest breaks had indirect effects on LBP that were mediated through psychological demand, and frequency of rest breaks was the most influential effector on psychological demand.

Conclusions: Three risk factors were identified to predict onset LBP, including history of LBP, frequency of rest breaks, and psychological demand. Each factor had direct effects on the development of LBP. Also, history of LBP and frequency of rest breaks had indirect effects on LBP that were mediated through psychological demand. (J Manipulative Physiol Ther 2018;41:405-412)

Key Indexing Terms: *Low Back Pain; Musculoskeletal Diseases; Computers; Etiology*

Introduction

Low back pain (LBP) has been reported to be a major problem for office workers, affecting 34% to 51% of workers annually.[1,2] Between 14% and 23% of office workers reported a new onset of LBP during the 1-year follow-up.[3,4] The annual prevalence of chronic LBP has been reported to range from 15% to 45%, with a point prevalence of 30%.[5] Consequently, LBP in effect constitutes a great socio-economic burden on patients and society. In the United States, the total cost of LBP in 2006 exceeded US$100 billion,[6] whereas in the Netherlands the total cost of LBP in 2007 was estimated at €3.5 billion.[7] The cost of LBP to society is likely to increase, given that many developing nations have been industrializing their economy, thus increasing the number of workers in the office environment at the global level.

The etiology of musculoskeletal disorders is widely accepted to be of multifactorial origin, including individual, physical, and psychosocial factors. Different occupations are exposed to different working conditions, and the nature of work influences the health of workers.[8] Predisposing factors for LBP are likely to be population specific. Research to identify the causal factors of a disease requires longitudinal research design, which permits the tracking of study participants' activities, health status, and exposures over time.[9] However, there have been a small number of high-quality prospective studies on the association between risk factors and the onset of nonspecific LBP in office workers. Very few risk factors were found to predict the onset of LBP in office workers; these included history of LBP and the combination of postural risk factors and job strain (for females only).[10]

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To understand the etiology of LBP, a model to conceptualize the process involved in the development of LBP is required. Wahlström[11] proposed the conceptual model for the association between musculoskeletal disorders and computer work, which emphasizes the association between work organization, psychosocial factors, and mental stress, as well as physical demands and physical load. It is hypothesized that work technology and organization have a direct path to physical demands. Both physical demands from work and mental stress may increase the physical load, which in turn has a direct path to perceived muscular tension. Individual factors are hypothesized to be an effect modifier for the association between physical demands and physical load, as well as the association between work organization and mental stress. Perceived muscular tension, along with perceptions of comfort and exertion, is hypothesized to be an early sign of musculoskeletal symptoms, which arises as a result of work organizational and psychosocial factors, as well as physical load and individual factors.

The purpose of this study was to use path analysis to develop a model for the association between various biopsychosocial factors and nonspecific LBP in a sample of office workers whose work involves computers. The analytical approach, such as path analysis, is a useful tool to test a causal pathway for the development of disease. Path analysis, which is an extension of multiple regression, can predict more than 1 dependent variable and assess the relationships among both independent and dependent variables within that model.[12,13] It shows a theoretical, directional relationship (both direct and indirect) between variables and offers a causal model of relationships.[14]

Methods

Participants and Procedure

A prospective cohort study with a 1-year follow-up was conducted in a convenience sample of office workers recruited from 9 large-scale workplaces. Office workers were defined as those working in an office environment with their main tasks involving use of a computer, participation in meetings, presentations, reading, and phoning. The enterprises participating in this study were public transportation, infrastructure, energy, and health enterprises; a public university; a police station; and the head offices of 3 ministries. The study was approved by Chulalongkorn University Human Ethics Committee.

Volunteers were screened into the study using a self-administered questionnaire. The inclusion criteria were individuals aged 18 to 55 years and working full time. Participants were excluded if they had reported musculoskeletal symptoms in the spine in the previous 3 months with pain intensity greater than 30 mm on a 100-mm visual analog scale (VAS); reported pregnancy or had planned to become pregnant in the next 12 months; had a history of trauma or accidents in the spinal region; or had a history of spinal, intra-abdominal, or femoral surgery in the previous 12 months. Participants who had been diagnosed with congenital anomaly of the spine, rheumatoid arthritis, infection of the spine and disks, ankylosing spondylitis, spondylolisthesis, spondylosis, tumor, systemic lupus erythematosus, or osteoporosis were also excluded from the study.

Office workers were approached and invited to participate in this study. At baseline, participants completed a self-administered questionnaire and underwent physical examination by trained physical therapists, according to standardized protocol. Participants then received a self-administered diary to record the incidence of LBP. The researcher returned to collect the diaries from participants every month over a 12-month period (Fig 1).

Outcome Measures

Nonspecific LBP is LBP (with or without radiation) without any specific systematic disease being detected as the underlying cause of the complaints.[15] A picture of the body from the standardized Nordic questionnaire[16] and the question "Have you experienced any LBP lasting >24 hours during the past month?" were included in a diary given to participants to assess onset of nonspecific LBP. If they answered "yes," follow-up questions about pain intensity, measured by a VAS, and the presence of weakness or numbness in the lower limbs were asked. In this study, participants were identified as cases if they answered "yes" to the first question, reported pain intensity >30 mm on a 100-mm VAS, and had no weakness or numbness in the lower limbs. Participants were followed until they became symptomatic, withdrew from the study, or completed the 12-month follow-up.

Biopsychosocial Risk Factors

The self-administered questionnaire and physical examination were used to assess potential biopsychosocial risk factors. The self-administered questionnaire comprised 3 sections designed to gather data on individual, psychosocial, and work-related physical factors. Individual factors included sex, age, marital status, educational level, frequency of regular exercise or sport, smoking habits, and number of driving hours a day. Work-related physical factors included current job position, number of working hours, years of working experience, frequency of using a computer, performance of various activities during work, and rest breaks. The questionnaire also asked respondents to self-rate the ergonomics of their workstations (desk, chair, and position of monitor) and work environment conditions (ambient temperature, noise level, light intensity, and air circulation). Psychosocial factors were measured

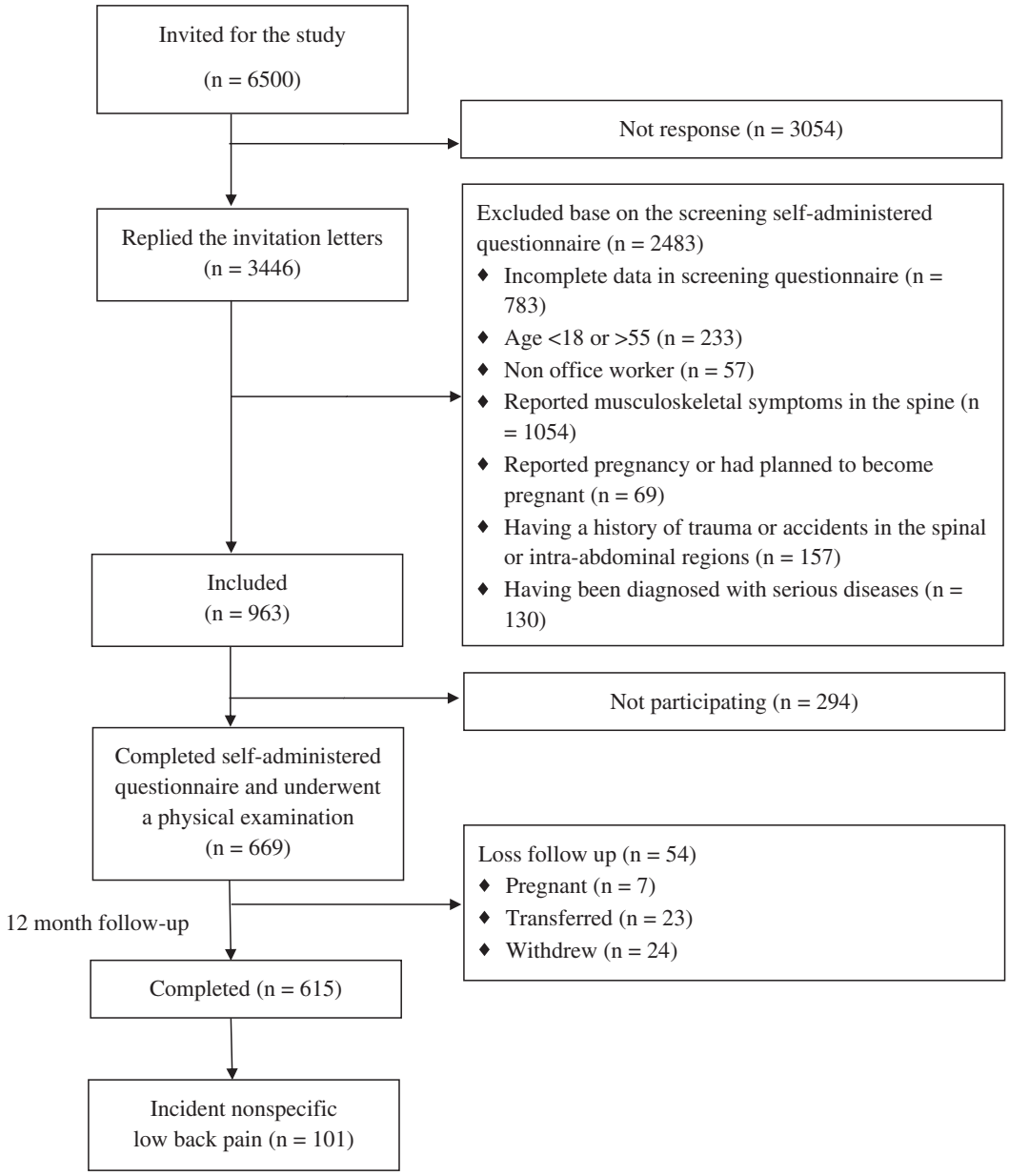

Fig 1. *Flow chart of participants.*

by the Job Content Questionnaire.[17] The questionnaire consisted of 54 items and constituted a set of questions for 6 scales, including job control, psychological demand, physical demand, job security, social support, and hazard at work. Each item had a response set of a 4-point Likert scale that ranged from 1 (strongly disagree) to 4 (strongly agree).

Each participant underwent a physical examination according to standardized protocol. Body weight and height were measured by digital scale and a wall-mounted stadiometer, respectively. Waist circumference was measured midway between the lower rib margin and the superior border of the iliac crest using a tape measure.[18] Trunk extension flexibility was assessed by the modified-modified Schöber test.[19] Erector spinae and multifidus muscle endurance was assessed by the Biering-Sörensen test.[20]

Before data collection, repeatability of data from the questionnaire and physical examination was assessed in 20 office workers. Each participant was tested on 2 occasions separated by an interim of 7 days between measurements for the questionnaire and 10 minutes for the physical examination.

Table 1. *Characteristics of Study Population (n = 669)*

Characteristic	N (%)	Mean ± SD
Demographic characteristics		
Sex		
Male	168 (25.1)	
Female	501 (74.9)	
Age (y)		35.7 ± 8.3
20-29	189 (28.2)	
30-39	265 (39.6)	
40-49	161 (24.1)	
≥50	54 (8.1)	
Education		
Lower than bachelor's degree	83 (12.4)	
Bachelor's degree	478 (71.5)	
Higher than bachelor's degree	108 (16.1)	
Exercise frequency in the past 12 mo		
Never	158 (23.6)	
Occasionally	429 (64.1)	
Regularly	72 (10.8)	
Not sure	10 (1.5)	
History of LBP		
Yes	525 (78.5)	
No	144 (21.5)	
Occupational-related characteristics		
Duration of employment (y)		10.7 ± 8.5
Working hours per day (h/d)		7.9 ± 1.1
Working days per week (d/wk)		5.0 ± 0.5
Frequent rest breaks		
Yes	543 (81.2)	
No	126 (18.8)	
Psychosocial characteristics		
Job control		35.0 ± 4.4
Psychological demand		32.3 ± 4.4
Physical job demand		13.4 ± 2.6
Job security		16.4 ± 1.9
Social support		30.6 ± 4.6
Hazard at work		16.7 ± 3.6
Physical characteristics		
Weight (kg)		60.3 ± 13.9
Height (cm)		160.1 ± 7.3
Body mass index (kg/m^2)		
<18.5 kg/m^2	70 (10.5)	
18.5-24.9 kg/m^2	409 (61.1)	
25-29.9 kg/m^2	126 (18.8)	
30 kg/m^2	64 (9.6)	
Waist circumference		77.7 ± 11.3
Trunk extension flexibility (cm)		13.0 ± 0.8
Erector spinae and multifidus endurance (s)		71.7 ± 38.0

LBP, low back pain; *SD,* standard deviation.

Statistical Analyses

For the reliability study, the intraclass correlation coefficient was calculated for continuous data and ϕ coefficient for nominal data. The intraclass correlation coefficient (3,1) was calculated for the questionnaire and physical examination outcomes.

Characteristics of participants were described using means or proportions. To retain the statistical power of the database, missing data were handled by the "hot-deck imputation" procedure. A respondent was selected at random from the total sample of the study, and the value for that person was assigned to the case in which information was missing. This procedure was conducted repeatedly for each missing value until the dataset was complete.[21]

Descriptive analysis and multiple regression were performed using SPSS for Windows Version 17.0 (IBM Corp, Armonk, New York), and path analysis was performed using LISREL Version 8.5 (Scientific Software International, Skokie, Illinois). To test the hypothesized model, a 3-step process analysis was undertaken. First, univariate logistic regression analysis was carried out to determine significant differences in the onset of nonspecific LBP with various biopsychosocial characteristics. Any factors with a P value ≤0.2 in the univariate logistic regression analysis were eligible for addition into multivariate analysis. Second,

Table 2. *Incidence and OR_{adj} With 95% CI of Nonspecific Low Back Pain With Respect to Factors in the Final Modeling (n = 615)*

Factors	N	Incidence (%)	OR_{adj}	95% CI	*P* Value
History of low back pain					
Yes	401	79 (19.70)	5.46	2.32-12.83	<.001
No	214	22 (10.28)	1.00		
Frequent rest breaks					
Yes	503	75 (14.91)	1.00		
No	112	26 (23.21)	1.69	1.01-2.84	.047
Psychological demand			1.07	1.01-1.12	.012

β Coefficient of psychological demand was assigned a score of 1, and then the other β coefficient was divided by 0.063 and rounded to the nearest integer.
CI, confidence interval; $OR_{adj,}$ adjusted odds ratio.

multivariate logistic regression was conducted to determine whether baseline measures of biopsychosocial risk factors were associated with incident LBP. Third, path analysis was used to examine the relationships among various factors and incident LBP, based on the model proposed by Wahlström.[11] The overall model fit was assessed by establishing fit indexes: the χ^2 significance test, the root mean square error of approximation (RMSEA), the comparative fit index, and the goodness-of-fit index. The χ^2 statistic was used where a nonsignificant test indicated that the model and data were consistent. The RMSEA is an index of the amount of misspecification of the model per degree of freedom, where values <0.05 indicate a good fit, values between 0.05 and 0.08 indicate a marginal fit, and values >0.1 indicate an unacceptable fit. Fit index values more than 0.95 are considered to indicate the acceptable fit of a model to data.[22]

Results

Test-Retest Reliability

The test-retest reliability results demonstrated fair (0.53) to excellent (1.00) reliability for self-administered questionnaire outcomes. Intrarater reliability for physical examination outcomes were good (0.72) to excellent (1.00).

Demographic Characteristics of Study Population

Of the total 6500 office workers who received a letter inviting them to participate in the study, 3446 responded (53%). Of these, 963 were eligible and 669 agreed to participate at baseline measurement. A total of 615 office workers were followed for 1 year (Fig 1). Table 1 presents the baseline characteristics of the study population. The sample population comprised mainly middle-aged women with bachelor's degrees. Their working time was typical for the office workers (ie, 8 hours per day, 5 days per week), and they had quite extensive working experience. Over the 12-month follow-up, 16.4% (101 of 615) of participants reported incidence of nonspecific LBP with the mean (standard deviation) VAS score of 47 (17) mm.

A Conceptual Model for the Onset of Nonspecific Low Back Pain in Office Workers

When performing univariate logistic regression analyses, variables with a *P* value ≤0.2 were weight, waist circumference, trunk extension flexibility, standing >2 hours, adjustable seat, ambient temperature, frequent rest breaks, history of LBP, physical demand, and psychological demand. Thus, these factors were selected for further analysis. Multivariate logistic regression analysis revealed a significant association between onset of LBP and history of LBP, frequency of rest breaks, and psychological demand (Table 2).

The causal relationships of history of LBP, frequency of rest during work, and psychological demand with onset of nonspecific LBP were examined by path analysis (Fig 2). All factors had a direct effect on the onset of nonspecific LBP in office workers. The most influential factor causing LBP was history of LBP (β = 0.17), followed by psychological demand (β = 0.10) and frequency of rest during work (β = 0.08), respectively. Factors mostly influencing psychological demand were frequency of rest during work (β = 0.11), followed by history of LBP (β = 0.05). Based on the fit indices of path analysis, this model provided a good fit for the data ($\chi^2 = 0.00$, $P = .99$, RMSEA < 0.001, goodness-of-fit index = 0.875, comparative fit index = 0.903).

Discussion

The present study examined the conceptual model for the association between nonspecific LBP and computer

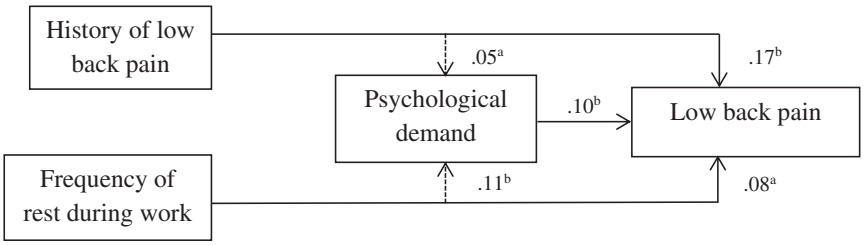

Fig 2. *Path analysis of factors predicting onset of nonspecific low back pain in office workers with standardized regression coefficients (*[a]*P < .05,* [b]*P < .01).*

work proposed by Wahlström[11] in a sample of office workers, whose work involves computers, using path analysis. Côté et al[8] suggested that risk factors for the onset of musculoskeletal disorders in a subpopulation may be a subset of risk factors identified in a general population or occupation specific. The results indicated that history of LBP, frequency of rest breaks, and psychological demand were 3 factors related to the development of nonspecific LBP in office workers, and history of LBP was the strongest effector on the onset of LBP in the model.

Wahlström[11] hypothesized that physical demands, which are the results of work technology and organization, directly affect physical load, which consequently relates to onset of musculoskeletal disorders. The results of the present study indicated that frequency of rest breaks may be an important indicator of physical demands in an office work environment. Office work usually requires prolonged sitting posture. Lack of movement during sitting may induce the shortening of soft tissues, which consequently limits the available joint range of movement.[23] Limited joint movement may distort the normal body biomechanics and contribute to musculoskeletal disorders.[24] One previous study showed that female adolescents with LBP had lower lumbar mobility in all directions than normal participants.[25] In addition, prolonged sitting requires the static contraction of postural muscles, which has been previously identified as a risk factor for musculoskeletal disorders.[26] Thus, rest breaks may reduce the adverse effect that prolonged sitting has on the lumbar spine, as mentioned previously, which predisposes the lumbar spine to injury.

In the model proposed by Wahlström,[11] individual factors are an effect modifier for the association between physical demands and physical load as well as the association between work organization and mental stress. In our study, history of LBP has a direct effect on onset of LBP and influences psychological demand. The results are in line with a recent systematic review of prospective cohort studies that reported strong evidence for the history of LBP as a risk factor of the onset of nonspecific LBP in office workers.[10]

Wahlström[11] hypothesized that mental stress may increase the physical load, which in turn has a direct path to perceived muscular tension. Perceived muscular tension, along with perceptions of comfort and exertion, is hypothesized to be an early sign of musculoskeletal symptoms. We found that psychological demand, measured by the Job Content Questionnaire,[17] was an important factor to predict LBP among office workers. In the working population, Linton,[27] in a systematic review of prospective cohort studies, reported moderate to strong evidence for job satisfaction, monotonous tasks, work relations, demands, stress, perceived ability to work, work pace, control, emotional effort at work, and the belief that work is dangerous. Vargas-Prada et al[28] reported that, after adjustment for sex, age, and occupation, new LBP was predicted by poor mental health, somatising tendency, and presence of LBP for >1 month in the year before baseline.

Côté et al[8] proposed that, rather than each risk factor only having direct effects on musculoskeletal disorders and the risk factors not being outcomes of antecedent risk factors themselves, musculoskeletal disorders are likely caused by multiple serial exposures. In other words, each risk factor has both direct and indirect effects on the development of musculoskeletal disorders. Some risk factors may exert their effects indirectly through other risk factors as a mediator. Our model of the development of nonspecific LBP in office workers revealed that history of LBP and frequency of rest breaks have indirect effects on LBP that were mediated through psychological demand. The results also pointed out that frequency of rest breaks was a more influential effector on psychological demand than history of LBP. The findings shed light on the notion that the body and mind are inextricably linked, and effective prevention of LBP should incorporate both physical and mental health interventions. To gain further insight into this issue, future studies on the association between frequency of rest breaks and psychological demand or stress are needed.

From the findings of the current study, the prevention of nonspecific LBP among office workers should at least focus on developing strategies or interventions to rectify frequency of rest breaks during work and to alleviate psychological demand. For the nonmodifiable risk factors (ie, history of LBP), this information is useful for clinicians to identify office workers at risk, which would mean the enhancement of resource allocation to those most in need and most likely to benefit from it. Otherwise, a large

number of people would receive intervention, which is likely to compromise its effectiveness.[29,30]

Strengths and Limitations

A major strength of this study is its prospective design, allowing for the identification of cause–effect relationships and the evaluation of a broad range of biopsychosocial factors for their contribution to nonspecific LBP in office workers. In addition, homogenous participants, in terms of working characteristics, were selected for the present study because different occupations are exposed to different working conditions, and the nature of work influences the health of workers. Consequently, predisposing factors for LBP are likely to be population specific. However, at least 2 main limitations are noteworthy. First, in this study, participants were identified as cases if they reported pain lasting more than 1 day, pain greater than 30 mm on a 100-mm VAS, and no weakness or numbness in the upper limbs. Different results may emerge with different definitions of symptomatic cases. Second, the nature of several biopsychosocial factors and the diagnosis of LBP were subjective, which may have led to data inaccuracy. An important drawback of self-reported data is the risk of overestimation of exposure.[31] Also, some workers may be more sensitive to any somatic disturbance than others. As a result, there is a risk of under- or overreporting of incidence. Future studies should consider the inclusion of objective information from a physical examination to increase data accuracy.

Conclusion

A conceptual model for the development of nonspecific LBP in office workers was developed using path analysis. Three risk factors were identified to predict onset of LBP, including history of LBP, frequency of rest breaks, and psychological demand. All 3 factors directly caused LBP, with history of LBP being the strongest effector on LBP. History of LBP and frequency of rest breaks had indirect effects on LBP that were mediated through psychological demand, with frequency of rest breaks being the most influential effector on psychological demand.

Funding Sources and Conflicts of Interest

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Contributorship Information

Concept development (provided idea for the research): P.J., R.S., E.S., A.P.
Design (planned the methods to generate the results): P.J., R.S., E.S., A.P.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): P.J.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): R.S., E.S.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): A.P.
Literature search (performed the literature search): P.J.
Writing (responsible for writing a substantive part of the manuscript): P.J.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): R.S., E.S., A.P.

Practical Applications

- A conceptual model for the development of nonspecific LBP in office workers is proposed, in which history of LBP, frequency of rest breaks, and psychological demand were directly related to LBP.
- History of low back pain and frequency of rest breaks had indirect effects on LBP that were mediated through psychological demand.
- Interventions aimed at preventing the occurrence of nonspecific LBP in the office environment should address these factors.

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