Incidence of Low Back Pain in Relation to Sedentary Workstation Design and Anthropometric Assessments

Sunisa Chaiklieng [ab], Pornnapa Suggaravetsiri [bc] and Jenny Stewart [d]

*[a] Department of Environmental Health Science
Faculty of Public Health, Khon Kaen University
[b] Back, Neck and Other Joint Pain Research Group, Khon Kaen University
Khon Kaen 40002, Thailand.*

*[c] Department of Epidemiology
Faculty of Public Health, Khon Kaen University
Khon Kaen 40002, Thailand*

*[d] Department of Rehabilitation
Faculty of Health and Environmental Science, AUT University
Auckland 1142, New Zealand*

ABSTRACT

This 12-months follow-up study aimed to investigate the incidence of low back pain (LBP) and the relations of workstation dimensions and workers anthropometry to LBP among office workers. Participants were 159 office workers from Khon Kaen University of Thailand. Data were collected by use of interview structured questionnaires, baseline measurements of workstation dimensions and anthropometric parameters. The finding of 12 months LBP incidence was 83.0%. The linear regression analysis for the linearity of the relationship between workstation dimensions and anthropometric parameters of office workers identified the linearity significance between the seat height and the popliteal height as well as the workspace (workstation) width and the sitting elbow height. The correlations of specific factors with LBP were analyzed by using t-test and chi-square test. The popliteal height, the buttock-popliteal length and the elbow height of LBP cases were significant smaller than those of non cases. The body mass index (BMI), the workspace width and the difference between the seat depth and buttock-popliteal length were significantly contributed to the occurrence of LBP. The findings are very useful for the design of the sedentary workstation. The suggestion is that the seat and workstation area should be optimized to individual worker in order to prevent LBP among office workers.

Keywords: Incidence, Low back pain, Ergonomics, Office workers, Anthropometry

INTRODUCTION

Persisting of low back pain (LBP) are common in society. The grobal prevalence of LBP by a systemetic review was estimated to 23.2% for the 1-month prevalence (Hoy et al, 2012). The annual prevalence of LBP ranges from 0.8% to 82.5% (mean: 38.1%) and estimates of recurrence at one year range from 24% to 80% (Hoy et al, 2010). LBP is obvious problem related to occupation correlated with sedentary work, particularly office worker with the one-month prevalence at the highest reported of 63.0% (Janwantanakul et al., 2011). The LBP prevalence among office workers at the school in Nagoya, Japan was reported to be 21.8% (Tsoboi et al., 2001), while a higher LBP prevalence (66.9%) was previously reported among university office workers in Thailand (Chaiklieng et al, 2010). The nature of office work composes of sedentary working activities. The continuous sitting and frequenly working in a forward bent position, particularly, under the conditions of poor workstation ergonomics has been shown to significantly contribute to the development of LBP (Janwantanakul et al., 2011). In addition, repetitively overhead or upward motions and prolonged awkward posture have been linked to increased risk of LBP (Chaiklieng and Suggaravetsiri, 2012). Studies investigating the relationship between LBP and risk factors of working conditions in office workers have postulated a number of factors. These include individual anthropometry (Andersson, 1999; Chiu et al., 2002), physical ergonomic factors i.e. prolonged sitting, awkward posture and working environment i.e. lifting, repetition, and work workstations (Fredriksson et al., 2002; Spyropoulos et al., 2007). While the high LBP prevalence was previously reported in university office workers (Chaiklieng et al. 2010), the working environment factors related to LBP were not yet clearly established. This study, therefore, aimed to investigate the incidence of LBP and the relations of workstation dimensions and workers anthropometric parameters to LBP among office workers.

MATERIALS AND METHODS

Recruitment of participants

The study was designed as a 12-month follow-up study among office workers in Khon Kaen University of Thailand. The sample size was calculated on the basis of one-year follow-up to estimate LBP incidence in this population. The estimation of sample size under the null hypothesis with one-sided test of incidence rate was used to calculate this (Lwanga and Lemeshow, 1991). The six-month incidence rate of LBP among university office workers was reported to be 35% (Mahmud et al., 2011). To test value of LBP incidence ($\lambda_0 = 0.35$) at the 5% level of significance using a power of test of 90%, the anticipated incidence rate (incidence rate >35%) was 45% (λ_a=0.45). Therefore a minimum sample size of 133 office workers was required. The sample size was increased by a further 20% to account for participants withdrawing or dropping out during the follow-up, therefore, the final sample size of LBP follow-up should not be less than 158 office workers.

All units in Khon Kaen university that provided name lists of office workers were included in computer program. After this process of simple random sampling for the screening group, participants were first invited and then interviewed before acceptance to this study. They were considered eligible for inclusion in the study if they were a full-time university employee, worked with computer for at least 4 hours per day, had at least one-year work experience at the current position, and were willing to participate. Participants were excluded if they had current low back pain (established by interview), a history of an episode of care of low back pain in the past three months or any specific medical condition affecting thoracic or lumbar spine (such as rheumatoid arthritis, degenerative disc disease, infection, tumors), a prolonged absence from work anticipated within the next 12 months or were pregnant. The final sample size for LBP follow-up was 159 office workers.

In this study, low back pain was defined as pain experienced in the spine area specifically from the lumbar vertebrae to the buttocks or gluteal folds, or between the lumbosacral vertebral prominences. This study obtained ethical approval from Khon Kaen University ethics committee, Thailand, No.HE522091. All participants gave informed consent prior to entering the study.

Data collection

Baseline measures and screening data were collected by face to face interviews with structured questions based on Chaiklieng et al. (2010)'s questionnaire which was divided into four parts. Part 1 enquired about demographic characteristics i.e. age, gender, work experience, second job or part time job. Part 2 enquired about health status, history of trauma, congenital diseases and chronic diseases (opened question), body mass index (BMI) based on the obesity measure for Thai people (BMI >25 kg/m^2) (Department of Health, Thailand, 2007). Part 3 enquired about working environment. Responses to the perception of work station dimensions i.e. width, height, and depth of the seat and the table or workstation were categorized as appropriate or inappropriate. Part 4 enquired about the current LBP, a history of an episode of care of low back pain in the past three months or any specific medical condition

The body weight, height, waist circumference (WC) and anthropometric characteristics were measured using standardized procedures with established reliability (Anthropometry, 2009; CDC, 2009). Measured anthropometric parameters were popliteal height, hip breadth, buttock-popliteal-length, sitting shoulder height, sitting elbow height and elbow height. Waist circumferences in centimeter (cm) were compared to the standard (80 cm of women and 90 cm of men) to identified obesity conditions (Department of Health, 2009). The dimensions of table, seat and workspace were measured at workstations by using steel measuring tape.

During the 12 month follow-up, the primary question that was asked at each fortnight follow-up was: "Have you experienced any low back pain lasting more than 24 hours during the past fortnight (Y/N)?" , applied from Hush et al. (2006). If a participant reported any onset of low back pain, more information was sought regarding date of onset, treatment sought, pain affecting work and daily activities and work loss. A positive response to any of the following questions confirmed that the low back pain was work-related: 1) Did your low back pain start at work? 2) Did your low back pain result from an injury or event at work? 3) Have you submitted a worker's compensation claim for this low back pain? 4) Did your health care provider specify that this is a work-related injury? In the event of a participant reporting an episode of low back pain, he/she continued to be followed up for a further period of one month to establish the severity of low back pain on the basis of health professional consultation or the period of work absence. If a subject reported the low back pain that was deemed not to be work-related (e.g. following an injury occurring outside of work hours), the subject was withdrawn from the study. If appropriate, advice to consult a health care practitioner was provided. The incidence rate was calculated at the period of 12-month follow-up in this study.

Data analysis

Data were recorded by Epi-info for Windows (Texas, USA, 2007) using a method of double data entry and the analysis was performed using STATA version 10.1. Descriptive statistics were used to describe the worker and workstation characteristics i.e. the percentage, mean and standard deviation (SD). LBP incidence was calculated at 12 months follow-up. Accumulated incidence rate of LBP = (Total number of new cases of LBP at 12-month period x 100) /159. No participants withdrew in this follow-up study. The analysis for the linearity of the relationship between workstation dimensions and anthropometric parameters of office workers was done by linear regression. The correlations of specific factors with LBP were analyzed by using t-test and chi-square test and significantly indicated at p-value <0.05.

RESULTS

Personal factors and health status

Among the sample of 159 university office workers, 76.7% were female (n=122) and 23.3% were male (n=37). The mean age was 33.8 ± 9.9 years (min = 23, max = 59). Regarding work experience, the mean value was 12.6 ± 10.1 years (min = 1, max = 39). The highest percentage of participants had work experience of 1-5 years (37.7%), followed by 16-20 years (17.0%) and 21-25 years (14.5%). According to the standard of nutritional status (Department of Health, 2009), 20.1% of workers were classified as being obese, identified by BMI >25 kg/m^2, 15.7% were overweight (>23.0-25.0 kg/m^2), 54.7% were of normal status (18.5-23.0 kg/m^2) and 9.4% were underweight. Most workers (79.2%) did not participate in regular exercise (at least 30 minutes, and 3 times a week). The factor of back pain found in a member of family was reported for 40.3%. Chronic diseases i.e. near sight, peptic alcers, high blood presssure were reported by 41.5% of workers.

Work environmental factors

While 95.0% of their office chairs had a backrest, and 43.4% were up-down flexible and 75.5% were revolvable, the height and width of the seats were ‘inappropriate’ in 71.7% and 72.3% of seats, respectively. Furthermore, when their table dimensions were measured, 66.0% and 63.5% were assessed as ‘inappropriate’ for height and width, respectively. Workspace width and depth were inappropriate in 66.7% and 75.5% of workstations, respectively.

Incidence of low back pain

The accumulated incidence of LBP across the 12 months was 83.0% (n=132). All cases were work-related LBP. The main reported cause of LBP was prolonged computer work or awkward posture. Sixty-two participants (46.9%) reported that LBP symptoms affected working quality and normal life. Eight participants (6.1%) reported receiving treatment from a heath professional and using drugs to ease the symptoms. Three participants (2.3%) went on sick leave because of LBP symptoms.

Workstation and anthropometric parameters

The linear regression analysis was performed to identified the linearity significance between the workstation dimensions and the anthropometric parameters of office workers. In comparison to the standard width of Thai office standard chair (40-45 cm), the seat width of workers (42-53 cm) was mostly bigger than the standard. The depth of seat (39-50 cm) was likely also bigger than thai office standard chair (38-44). For the relationship between measurements parameter of workstations and anthropometric parameters of office workers, the results indicated the linearity significance between seat height and popliteal height at p-value = 0.005. Interestingly, the significant regression between workspace width and sitting elbow height was found at p-value < 0.001 (see Table 1).

Table 1: Results of dimension measurements of workstations (n=159) and anthropometric parameters of office workers (n=159).

Workstation/ body size	**Dimension parameters**	**Size (cm)**				P-value**
		5th percentile	50th percentile	95th percentile	Mean (SD)	
Seat	Height (a)	38	45	54	45.1 (4.5)	
	Width (b)	42	46	53	46.6 (3.2)	
	Depth (c)	39	43	50	43.8 (3.2)	
	Backrest height (d)	39	49	63	48.9 (7.1)	
Table	Height (e)	74	75	76	75.2 (1.1)	
	Width	90	150	240	157.0 (51.6)	
	Depth	59	80	81	72.0 (10.2)	
Workspace	Width (f)	56	108	200	111.8 (53.4)	
	Depth	28	50	80	52.3 (17.0)	
Body	Popliteal height (g)	39	47	53	45.8 (4.7)	0.005[A]
	Hip Breadth (h)	32	37	48	38.0 (4.9)	0.792[B]
	Buttock-popliteal length(i)	36	46	58	46.5 (7.1)	0.783[C]
	Sitting shoulder height (j)	48	54	60	53.3 (5.5)	0.340[D]
	Elbow height (k)	58	72	83	71.0 (7.6)	0.652[E]
	Sitting elbow height (l)	18	24	35	24.5 (5.1)	<0.001[F]

Remark:

p-value** = using linear regression for linearity of the relationship between measurements parameter of workstations and anthropometric parameters of office workers

A: linearity significant between seat height (a) and popliteal height (g) at p-value = 0.005

B: linearity non-significant between seat width (b) and hip breadth (h) at p-value = 0.792

C: linearity non-significant between seat depth (c) and buttock-popliteal length (i) at p-value = 0.783

D: linearity non-significant between backrest height (d) and sitting shoulder height (j) at p-value = 0.340
E: linearity non-significant between table height (e) and elbow height (k) at p-value =0.652
F: significant regression between workspace width (f) and sitting elbow height (l) at p-value <0.001

The relations of anthropometric parameters and workstation dimensions to LBP

The correlation of the anthropometric parameters to low back pain were identified by t-test with equal variances between cases and non cases. The analysis indicated that the popliteal height, the buttock-popliteal length and the elbow height of LBP cases were significant smaller than those of non cases (see Table 2).

To identify the specific factors in relation to LBP, the chi-sqaure test was analysed. The anthropometric parameter which was significantly correlated with LBP was BMI and the workstation dimension which was significantly correlated with LBP was workspace (workstation) width. Moreover, the difference between the seat depth and buttock popliteal length of workers was significantly contributed to the occurrence LBP (see Table 3).

Table 2: Personal and anthropometric characteristics correlated with LBP among 159 University office workers.

Characteristics	**Low back pain**		
(mean±SD)	**Cases (n=132)**	**Non-cases (n=27)**	**P-value**
Age (year)	38.1±9.6	39.5±11.5	0.496
Work experience (year)	12.2±9.9	14.2±10.8	0.351
Height (cm)	159.5±6.9	160.8±9.4	0.406
Body weight (kg)	56.2±9.4	59.6±13.6	0.128
Waist circumference (cm)	75.5±9.4	79.6±12.0	0.054
Popliteal height (cm)	45.2±4.6	48.3±4.1	0.002*
Hip breadth (cm)	37.8±5.0	38.7±4.3	0.392
Buttock-popliteal length (cm)	45.4±6.8	51.6±5.8	< 0.001*
Sitting shoulder height (cm)	53.4±5.2	52.8±6.9	0.610
Sitting elbow height (cm)	24.7±5.2	23.3±4.1	0.187
Elbow height (cm)	70.2±7.7	74.9±5.3	0.003*

Remark: * Indicates significant difference by t-test with equal variances at p-value <0.05

Table 3: Factors related to low back pain among 159 University office workers.

Variables	Low back pain Cases n (%)	Low back pain Non-cases n (%)	P-value
Gender			0.937
Male	26 (72.2)	10 (27.8)	
Female	83 (71.6)	33 (29.4)	
Exercise			0.521
Yes	52 (74.3)	18 (25.7)	
No	37 (68.5)	27 (30.3)	
Table height (by questionnaires)			0.523
Inappropriate	77 (73.3)	28 (26.7)	
Appropriate	37 (68.5)	17 (31.5)	
Seat height (by questionnaires)			0.621
Inappropriate	83 (72.8)	31 (27.2)	
Appropriate	31 (68.9)	14 (31.1)	
Difference between seat depth and buttock-popliteal length (cm)			0.008*
> 0	55 (93.2)	4 (6.8)	
≤ 0	77 (77.0)	23 (23.0)	
Difference between table height and elbow height (cm)			0.750
> 0	74 (32.6)	28 (27.4)	
≤ 0	40 (70.2)	173 (29.8)	
Workspace width			0.007*
Inappropriate	94 (88.7)	12 (11.1)	
Approprivate	38 (71.1)	15 (28.2)	
BMI (kg/m^2)			
≤ 25	110 (86.6)	17 (13.4)	0.020*
> 25	22 (68.8)	10 (31.2)	

Remark: *Indicates significant difference by chi-square test at p-value <0.05

DISCUSSION

There would appear to be a high incidence over a 12-month follow-up period of low back pain among Thai university-based office workers (83.0%). The finding of a high accumulated incidence of LBP supports the high prevalence found in the authors' previous study (Chaiklieng, et al 2010). The use of a prospective cohort with frequent regular follow-up contacts with the subjects over the entire follow-up period in the present study minimised the risk of recall bias and adds further strength to this finding of a high incidence of LBP in this occupational group working with sedentary workstation.

Although, cases of LBP have been reported in lower incidence among academic based office workers in university of Hong Kong (Chiu et al. 2002), in Malaysia (Mahmud et al., 2011), and in a school in Japan (Tsuboi et al. 2001). The higher incidence in the present study may be explained by the difference in eligibility criteria. In the Malaysian study, subjects were selected if they worked on computer for at least three hours per day. In the present study, the criterion was at least four hours per day, and this difference may have been crucial in the determination of risk for LBP.

The nature of office work with computers involves sitting in a fixed position in front of screen or typing documents and performing numerical tasks for at least four hours a day. In the present study, as in anather studie (Spyropoulos, 2007), inappropriate workstation design appeared to have a potential role in provoking the onset of LBP symptom. Moreover, it was noticeable that office workers with BMI ≤ 25 kg/m^2 were more at risk for the development LBP than those with BMI >25 kg/m^2. As previously reported by the authors (Chaiklieng, 2010), it seems likely that the non-optimized physical dimensions of the workstations of individual workers may have contributed to the development of LBP. This would be particularly the case for those who were small and spent a prolonged period of time working with a computer. LBP is a chronic disorder in that the symptoms can often reoccur when expose to the risk factors (Hoy et al., 2010). Even after completing successful treatment, repeated episodes of LBP seem likely when someone is re-exposed to the same risk factors from personal factors or work ergonomic factors (Hoy et al., 2010).

Another important finding to emerge from the present study was the relationship between non-optimized workstation and LBP from the significant identication factor of the difference between the seat depth and buttock popliteal length. This suggests that office workers should be more aware for workstation design to be fit each individual anthropometric size. Inappropriate workstation and seat dimension are the hazard conditions which might play a role on developing of low back pain. In additions, the organization should provide good ergonomic design workstation in offices and the LBP surveillence program as well as health promotion program among office workers.

CONCLUSIONS

The results provide an indication of the nature of hazards affecting LBP in office workers. The incidence of LBP found at the period of 12-month follow-up was 83.0%. Linear regression analysis identified the linearity significance between the popliteal height of worker and the seat height, and the significant regression between the sitting elbow height and workspace (workstation) width. The seat width and the depth of workers were likely bigger than Thai office standard chair. In relations to the LBP occurrence, the popliteal height, the buttock-popliteal length and the elbow height of LBP cases were significantly smaller than those of non cases. The specific factors which were BMI, workspace width, and the difference between the seat depth and buttock popliteal length of workers significantly contributed to the occurrence of LBP

The findings are very useful for the design of the sedentary workstation dimension and recommend that the physical dimension of seat, table and workspace should be optimized to individual worker, especially had a small size. In order to prevent LBP in office workers, it is proposed that ergonomics design of the workspace (width and level) and seat (depth, width and height) should be considered that adhere to safety office standards and fit to individual workers.

ACKNOWLEDGEMENT

This study was supported financially by Khon Kaen University, Khon Kaen, Thailand

REFERENCES

Andersson, G.B.J. (1999), “Epidemiological features of chronic low-back pain”, Lancet, 354, 581-585.

Anthropometry. [online], Available at URL http://personal.cityu.edu.hk/~meachan /online%20Anthropometry/Chapter5/Ch5-5.htm, accessed September 25, 2009

Centers for Disease Control and Prevention (CDC). “Body measurement (Anthropometry) Manual”, Available at URL http://www.cdc.gov/ncsh /data/nhanes/nhanes3/cdrom/ncsh/manuals/anthro.pdf, accessed September 25, 2009

Chaiklieng, S., Suggaravetsiri, P., Boonprakob, Y., (2010). “Work ergonomic hazards for musculoskeletal pain among university office workers”. Walailak Journal of Science and Technology, 7, 169-176

Chaiklieng S, Suggaravetsiri P. (2012), “Risk factors for repetitive strain injuries among school teachers in Thailand”, WORK: A Journal of Prevention, Assessment & Rehabilitation, 42, 2510-2515.

Chiu, T.T.W., WY, K., Lee, M.H., Sum, M.H., Wan, M.P., Wong, C.Y., et al. (2002), “A study on the prevalence of risk factors for neck pain among university academic in Hong Kong”, Journal of Occupational Rehabilitation, 12, 77-91.

Department of Health, Ministry of Public Health. Devision of Nutrition [online], Available at URL http://nutrition.anamai.moph.go.th/, accessed March 25, 2009

Fredriksson, K., Alfredsson, L, Ahlberg, G., Josephson, M., Kilbom, A., Jelm, E.W., et al. (2002), "Work environment and neck and shoulder pain: the influence of exposure time. Results from a population based case-control study", Occupational and Environmental Medicine, 59, 182-188.

Hoy, D., Bain, C., Williams, G., March, L., Brooks, P., Blyth, F., Woolf, A., Vos, T. (2012), "A systemetic review of the global prevalence of low back pain", ARTHRITIS & RHEUMATISM, 64 (6), 2028-2037.

Hoy, D., Brooks, P.,Blyth, F., Buchbinder, R. (2010), "Epidemiology of low back pain", Best Practice & Research Clinical Rheumatology, 24(6), 769-781.

Hush, J.M., Maher, C.G., Refschalke KM. (2006), "Risk factors for neck pain in office workers: a prospective study". BMC Musculoskeletal Disorders, 7(81), 1471-1474.

Janwantanakul, P., Pensri,P., Moolkay, P. Jiamjararangsi, W. (2011), "Development of a risk score for low back pain in office workers-a cross-sectional study", BMC Musculoskeletal Disorders, 12, 23.

Lwanga, S.K, Lemeshow, S. (1991), Sample size determination in health studies: a practical manual. Geneva: World Health Organization

Mahmud, N., Kenny, D.T., Zein, R.M., Hassan, S.N. (2011), **"**Ergonomic training reduces musculoskeletal disorders among office workers: results from the 6-month follow-up"**,** Malaysian Journal of Medical Science , 8(2), 16-26.

Spyropoulos, P., Papathanasiou, G., Georgoudis, G., Chronopoulos, E., Koutis, H., Koumoutsou, F. (2007), "Prevalence of musculoskeletal pain in Greek public office workers", Pain Physician, 10, 651-660.

Tsuboi, H., Takeuchi, K., Watanabe, M., Hori, R., Kobayashi, F. (2001), "Psychosocial factors related to musculoskeletal pain among school personnel in Nagoya, Japan", Japan Industrial Health, 40, 266-270