Low Back Pain among Professional Bus Drivers: Ergonomic and Occupational-Psychosocial Risk Factors

Deborah Alperovitch-Najenson PT PhD[1], Yoav Santo PhD[2], Youssef Masharawi PT PhD[1], Michal Katz-Leurer PT PhD[1], Diana Ushvaev MSc[3] and Leonid Kalichman PT PhD[4]

[1]Department of Physical Therapy, Steyer School of Health Professions, Tel Aviv University, Ramat Aviv, Israel
[2]Sigo Consultants, Tel Aviv, Israel
[3]Department of Psychology, Tel Aviv University, Ramat Aviv, Israel
[4]Department of Physical Therapy, Recanati School for Community Health Professions, Faculty of Health Sciences, Ben-Gurion University of the Negev, Beer Sheva, Israel

ABSTRACT: **Background:** Professional drivers have been found to be at high risk for developing low back pain. However, the exact reasons are poorly understood.

Objectives: To assess the prevalence of LBP among Israeli professional urban bus drivers, and evaluate the association between LBP in drivers and work-related psychosocial and ergonomic risk factors.

Methods: A total of 384 male full-time urban bus drivers were consecutively enrolled to this cross-sectional study. Information on regular physical activity and work-related ergonomic and psychosocial stressing factors was collected during face-to-face interviews. The prevalence of LBP was assessed using the Standardized Nordic Questionnaire.

Results: From the total cohort, 164 bus drivers (45.4%) reported experiencing LBP in the previous 12 months. Ergonomic factors associated with LBP were uncomfortable seat (odds ratio 2.6, 95% confidence interval 1.4–5.0) and an uncomfortable back support (OR 2.5, 95% CI 1.4–4.5). In the group of drivers with LBP, 48.5% reported participation in regular physical activities vs. 67.3% in the group without LBP ($P < 0.01$). The following psychosocial stressing factors showed significant association with LBP: "limited rest period during a working day" (1.6, 1.0–2.6), "traffic congestion on the bus route" (1.8, 1.2–2.7), "lack of accessibility to the bus stop for the descending and ascending of passengers" (1.5, 1.0–1.5), and "passengers' hostility" (1.8, 1.1–2.9).

Conclusions: Work-related ergonomic and psychosocial factors showed a significant association with LBP in Israeli professional urban bus drivers. Prevention of work-related stress, organizational changes targeted to reduce stressful situations, improvement in seat comfort, and encouraging regular sports activity need to be evaluated as prevention strategies for LBP in professional bus drivers.

IMAJ 2010; 12: 26–31

KEY WORDS: low back pain, bus drivers, risk factors, stress

LBP = low back pain
OR = odds ratio
CI = confidence interval

Work-related musculoskeletal disorders, especially low back pain, cause substantial economic losses to individuals as well as to the community. Professional drivers have been found to be at high risk for developing LBP due to prolonged sitting and vehicle vibration [1-5]. Among the different types of work-related musculoskeletal disorders that could potentially be associated with professional driving, LBP has been reported the most extensively [2,4-6]. A study on the prevalence of LBP in bus drivers, truck drivers, and sedentary workers indicated that 81% of American bus drivers and 49% of Swedish bus drivers have experienced LBP during their present job [2]. Male truck drivers were four times more likely than sedentary workers to develop a herniated lumbar disk [7], and 80% of motor coach operators have experienced back or neck pain as compared to 50% of non-drivers [1].

Importantly, work-related musculoskeletal disorders in professional drivers are associated with both ergonomic and psychosocial risk factors. The most commonly identified physical factors are prolonged sitting, whole-body vibration, ergonomic mismatch among drivers (disparity between anthropometric sizes of the drivers and their physical environment), the type of vehicle seat, and driving mechanisms (automatic or not automatic, etc.) [2,5-7]. Individual factors such as age, gender, weight, height, body mass index, and general health status are also associated with the work-related ailments of drivers [2,3].

Numerous studies have indicated the importance of psychosocial factors (job satisfaction, mental demands, poor supervisor ratings, etc.) regarding the incidence of LBP and injury among professional drivers [2,4,8]. In a large study of 1449 urban transit drivers, high levels of psychological demands and job dissatisfaction were strongly correlated with reported spinal injuries [7] and absenteeism [2,8]. Psychosocial stress among professional bus drivers might be caused by factors such as difficult traffic conditions, passenger hostility, short lunch breaks, or lack of accessibility to the lavatory. This stress can cause muscle tightness, mechanical strain on spinal structures, and fatigue that could lead to traumatic injury [9]. We did not find any study that directly assessed the association between the psychosocial stressing factors (e.g., difficult traffic conditions and passenger hostility) and LBP in professional bus drivers.

The aims of this study were twofold: to assess the prevalence of low back pain among Israeli professional urban bus drivers, and evaluate the association between and work-related psychosocial and ergonomic risk factors.

SUBJECTS AND METHODS

This cross-sectional study was conducted among urban bus drivers employed by the largest public transportation company in the Tel Aviv Metropolitan region. This company employs about 15,000 bus drivers. A total of 384 full-time male bus drivers were randomly recruited to the study, regardless of their health status and the presence of LBP. Since the number of female bus drivers was negligible, they were excluded from the study. Drivers with a history of traumatic road or work accidents were also excluded from the study. All subjects signed an informed consent form. The study was approved by the Human Ethics Committee (Helsinki) of Reut Hospital, Tel Aviv. The population was cooperative, and only 12 drivers declined to participate in the study for personal reasons. Each subject participated in a face-to-face interview in which he was asked his age, stature, weight, sports and physical activity, and health status (chronic morbidity). During the interview, the study participants completed a questionnaire on ergonomic and psychosocial stressing factors.

ERGONOMIC AND PSYCHOSOCIAL STRESSING FACTORS

A pilot qualitative study was initially conducted to develop a questionnaire for evaluating work-related ergonomic and psychosocial stress factors among professional bus drivers. Fifteen randomly selected drivers were observed by an experienced ergonomic and occupational health researcher (D.A-N.) during their driving sessions. This was followed by interviews to discuss the observations. Based on the observations, interviews and a review of the literature, the first variant of the questionnaire was developed. This questionnaire was used to conduct pilot face-to-face interviews to identify possible sources of misinterpretations and interviewer biases. The final version of the questionnaire and the precise protocol of the interview were then designed. To minimize possible interviewer biases, all interviewers studied the protocol of the interview and were specially trained in interviewing techniques.

The final variant of the questionnaire included two parts: The first, the ergonomic questionnaire, evaluated the comfort of the workstation, such as the seat, back support and steering wheel, which were evaluated on a Likert-type four-point scale (4 = very comfortable, 3 = comfortable, 2 = uncomfortable, and 1 = very uncomfortable). The second assessed work-related psychosocial stressing factors, i.e., the bus driver's stress level in specific situations that he encounters in his everyday work. Responses were ranked using a Likert-type six-step scale (6 = extremely stressful, 5 = very stressful, 4 = moderately stressful, 3 = mildly stressful, 2 = slightly stressful, and 1 = not stressful at all). The following statements were tested: "the rest period is too short during the working day," "traffic congestion on the bus route," "lack of accessibility to the bus stop for the descending and ascending of passengers," "the lunch break is too short," "lack of accessibility to the lavatory," "not enough time for exchanging money and buying tickets at the cashier" (in Israel, when the bus driver returns to the central bus station he deposits the money with the cashier and receives a new set of tickets), and "passengers' hostility."

The ergonomic and psychosocial stressing factors were converted to dichotomous variables. In the ergonomic data, answers of "very comfortable" (ranking 4) or "comfortable" (ranking 3) were considered as comfortable, and answers of "uncomfortable" (2) or "very uncomfortable" (1) were considered as uncomfortable. In the psychosocial data, the answers "extremely stressful" (6) and "very stressful" (5) were considered as stressful, whereas all other answers were considered as "not stressful."

LBP EVALUATION

All study participants were asked to complete the modified Nordic Low Back Pain Questionnaire [10]. They were asked if they had LBP during the last 12 months (ache, pain or discomfort) for a day or longer. Those responding "yes" were included in the LBP group and were asked to indicate on a body chart all sites of pain and discomfort they have experienced. All others responding with "no" were assigned to the non-LBP group. Similar methods are widely used in studies of work-related LBP.

STATISTICAL ANALYSIS

The differences between groups (individuals with and without LBP) were examined by Student's t-test (for continuous variables) and a $\chi 2$ test (for categorical variables). The differences in individual characteristics, ergonomic and psychosocial factors between groups with and without LBP were examined by a $\chi 2$ test and the associations were described by the odds ratio with 95% confidence interval. Logistic regression analysis was performed to evaluate the association between individual characteristics, ergonomic and psychosocial risk factors, and occurrence of LBP. In addition, all independent variables with significant associations were included in the multivariate logistic regression model. A stepwise procedure was used with entry probability of 0.05, and removal of 0.10. For the final model, OR and 95% CI were calculated.

IMAJ • VOL 12 • JANUARY 2010

RESULTS

The study group comprised 361 male bus drivers. Among them, 164 drivers (45.4%) complained of LBP and were included into the LBP group; another 197 drivers (54.6%) were included in the non-LBP group [Table 1]. The drivers in the LBP group were significantly younger than the drivers in the non-LBP group (mean age 45.0 ± 9.5 years and 47.0 ± 10 years, respectively, $P = 0.04$). Drivers in both groups were on average overweight (mean BMI 27.2 ± 3.9 for the LBP group, 26.8 ± 3.8 for the non-LBP group). The prevalence of chronic diseases was distributed equally between the groups.

The prevalence of drivers who participated in regular physical activities was significantly higher in the non-LBP group (67.3%) than the LBP group (48.5%) ($P < 0.01$). No difference between the two groups was found in relation to the prevalence of tenure position or the seniority of the drivers.

The results of a comparison between drivers with and without LBP regarding comfort of the workstation and psychosocial stressing factors are shown in Table 2. Drivers with LBP more frequently complained of uncomfortable seats (OR 2.6, 95% CI 1.4–5.0) and uncomfortable back support (2.5, 1.4–4.5). There was no significant difference between the groups in the reporting of an uncomfortable steering wheel (1.4, 0.7–2.7).

Regarding psychosocial stressing factors, there was a significantly higher proportion of complaints in the LBP group about having a limited rest period during a working day (1.6, 1.0–2.6), traffic congestion on the bus route (1.8, 1.2–2.7), the lack of accessibility to the bus stop for the descending and ascending of passengers (1.5, 1.0–1.5), and passenger hostility (1.8, 1.1–2.9). There was no difference in complaints or other psychosocial stressing factors between groups.

The results of the logistic regression analysis revealed three main variables associated with LBP in professional urban bus drivers [Table 3]: regular physical activity (2.13, 1.37–3.31), an uncomfortable seat (2.20, 1.16–4.18), and complaints of a traffic jam on bus routes (1.66, 1.07–2.57). The proportion of the variance that was explained by the model was 10% (Nagelkerke R-square = 0.10).

Table 1. Descriptive statistics of the studied sample, by low back pain in the previous last year

	With LBP (n=164)	Without LBP (n=197)	*P* value*
Individual and work characteristics			
Age (yrs)	45.0 ± 9.5	47.0 ± 10.0	**0.04**
Stature (m)	1.75 ± 0.07	1.74 ± 0.07	0.63
Weight (kg)	83.8 ± 14.3	82.4 ± 14.3	0.34
BMI (kg/m^2)	27.2 ± 3.9	26.8 ± 3.8	0.35
Tenure position	46 (28.8%)	60 (31.1%)	0.35
Seniority (yrs)	17.1 ± 10.2	18.9 ± 11.5	0.61
Regular physical activity	79 (48.5%)	132 (67.3%)	**0.01 >**
Health-related characteristics			
Hypertension	23 (14.0%)	21 (10.7%)	0.34
Chronic heart diseases	5 (3.0%)	9 (4.6%)	0.45
Diabetes mellitus	5 (3.0%)	13 (6.6%)	0.12

Student's *t*-test for continuous variables, $\chi 2$ test for dichotomous variables. Statistically significant differences ($P < 0.05$) are marked in bold.

Table 2. Self-perceived occupational risk factors, by low back pain in the previous year

		With LBP (n=164)	Without LBP (n=197)	*P* value*	OR	95% CI
Workstation factors	Uncomfortable seat	34 (20.7%)	18 (9.1%)	**< 0.01**	**2.6**	**1.4–5.0**
	Uncomfortable back support	41 (25.0%)	23 (11.7%)	**< 0.01**	**2.5**	**1.4–4.5**
	Uncomfortable steering wheel	21 (12.8%)	19 (9.6%)	0.34	1.4	0.7–2.7
Psychosocial stress factors	Inadequate rest period during the working day	64 (39.3%)	55 (28.1%)	**0.02**	**1.6**	**1.0–2.6**
	Traffic congestion on bus routes	98 (60.5%)	90 (45.7%)	**< 0.01**	**1.8**	**1.2–2.7**
	Lack of accessibility to the bus stop for the descending and ascending of passengers	86 (52.8%)	82 (41.6%)	**0.03**	**1.5**	**1.0–1.5**
	Lunch break too short	36 (22.1%)	38 (19.4%)	0.52	1.1	0.7–1.9
	Lack of accessibility to the lavatory	53 (32.5%)	48 (29.4%)	0.08	1.5	0.9–2.4
	Not enough time for exchanging money and buying tickets at the cashier	33 (20.2%)	31 (15.8%)	0.27	1.3	0.7–2.3
	Exposure to passenger hostility	49 (30.2%)	38 (19.4%)	**0.01**	**1.8**	**1.1–2.9**

Statistically significant differences ($P < 0.05$) are marked in bold.

Comparison tests: Student's *t*-test for continuous variables, χ^2 test for dichotomous variables.

DISCUSSION

The present study evaluated the association between work-related ergonomic and psychosocial stressing factors and LBP in Israeli professional urban bus drivers. The main results of our study were as follows:

- A high (45%) 12 month prevalence of LBP among professional urban bus drivers
- Traffic congestion on bus routes, passenger hostility, too short a rest period during a working day, and the lack of accessibility to the bus stop for the descending and ascending of passengers are possible psy-

BMI = body mass index

chosocial stressing factors associated with LBP among bus drivers

- An uncomfortable seat and back support are associated with a higher prevalence of LBP
- Participating in sports activities is associated with a lower prevalence of LBP.

Table 3. Logistic regression (final model): LBP at the last year as a dependent variable

					95.0% CI for Exp(ß)	
Predictors	**ß**	**SE**	**Wald**	**Exp(ß)**	**Lower**	**Upper**
Non-participation in sports activities	0.756	0.225	11.308	2.130	1.371	3.311
Uncomfortable seat	0.790	0.327	5.812	2.202	1.159	4.184
Traffic congestion on bus routes	0.506	0.223	5.143	1.659	1.071	2.568

$r^2 = 10.0$, $\chi^2 = 23.0$, $P < 0.01$

ß = regression coefficient, SE = standard error, Wald = $(ß/SE)^2$, Exp(ß) = odds ratio

THE PREVALENCE OF LBP IN PROFESSIONAL URBAN BUS DRIVERS

Our study indicated a 45% prevalence of LBP among Israeli professional bus drivers. This finding is comparable with a recent report by Robb and Mansfield [11] who found a 60% prevalence of LBP among professional truck drivers over 12 months, and with another study among Taipei urban taxi drivers where the prevalence was 51% over 12 months [5]. Netterstrøm and Juel [12] evaluated the occurrence of LBP among 2045 professional urban bus drivers in Denmark and found a 57% prevalence of frequent LBP. Magnusson et al. [2] studied a group of American and Swedish bus drivers and found a 60% prevalence of LBP, which required, on average, 18 days sick leave. Compared with a group of truck and sedentary workers, the bus drivers experienced far more episodes of back pain than did non-drivers. The relatively lower prevalence of LBP that was found in the present study can probably be attributed to a new type of bus that was introduced a few years ago in Israel. The 12 month LBP prevalence is still very high among urban bus drivers and additional studies are needed to both identify the hazards and develop prevention strategies.

PSYCHOSOCIAL STRESSING FACTORS

Relatively few studies have been conducted on the relationship between work-related psychosocial stress factors and musculoskeletal disorders. A prospective study of employees at a Boeing aircraft factory in Seattle, Washington found that psychosocial factors such as job dissatisfaction and poor supervisor ratings in the previous 6 months were predictive of back injury reporting [13].

A review by Bongers and co-authors [14] on the association between psychosocial factors and musculoskeletal disorders concluded that, because of the limited assessment of the physical workload, none of the studies presented conclusive evidence for an independent effect of work-related psychosocial factors. In a review published in 1997 by the National Institute for Occupational Safety and Health [15], it was concluded that psychosocial factors may represent generalized risk factors for musculoskeletal disorders, but that it was difficult to determine the relative importance of physical and psychosocial factors.

Work-related psychosocial stressing factors such as job satisfaction, stress, mental demands, and poor supervision ratings were previously found to correlate with the incidence of LBP among professional drivers [2,4,8]. Krause and team [4], in a 5 year prospective cohort study of 1449 transit operators, found that psychological job demands, job dissatisfaction, and the high frequency of job-related problems were predictors of workers' compensation claims due to spinal injuries. Marginally significant associations were found for low supervisor support. Job strain, low decision latitude, and low co-worker support were not related to the incidence of spinal injuries.

In the present study, four stressful situations showed a statistically significant association with LBP: traffic congestion on the bus route, passenger hostility, inadequate rest period during the working day, and lack of accessibility to the bus stop for the descending and ascending of passengers. To the best of our knowledge, most of the aforementioned factors were not previously evaluated for bus drivers. A short resting period was previously found to be associated with LBP (OR 2.4) in truck drivers [16].

The exact mechanism underlying the association between work-related psychosocial stressing factors and LBP is still uncertain [17]. The major hypotheses include direct neurogenic effects of psychological demand on muscle tension and the ensuing biomechanical strain and stress-related endocrine effects on musculoskeletal function [18]. Specifically for the topic of the present study, Svensson and Andersson [9] proposed that psychological stress contributes to increased tone in musculature, consequently causing increased mechanical strain on spinal structures. It also produces fatigue that could predispose drivers to traumatic injury. Competing hypotheses involve the direct effects of psychosocial factors or the psychological strain regarding the perception and attribution of symptoms [17].

ERGONOMIC RISK FACTORS

Although sitting while driving is not equivalent to sedentary work, many experimental studies have investigated the link between a sitting posture and LBP. Early studies have indicated that sitting without lumbar support and a backrest could increase disk pressure [19] and the electromyographic activities of back muscles [20]. These findings led to the general belief that prolonged sitting is harmful to the lumbar spine; interestingly, sitting was even classified as a risk factor for LBP. However, the postulated harmful effect of prolonged sitting was not fully supported by epidemiological data. Recently, Lis and colleagues [21], in their systematic review, found that sitting itself does not increase the risk of LBP, but sitting for more than half a workday, combined with whole-body vibration and/or awkward postures, does increase the likelihood of having LBP and/or sciatica, and it is the combination of those risk factors that leads to the greatest increase in LBP. Moreover, the epidemiological cross-sectional study of Chen et al. [22] showed a significant association among seat inclination, use of lumbar support, and LBP.

In the present study, an uncomfortable seat and uncomfortable back support were associated with a higher prevalence of LBP among professional bus drivers. Bus drivers often maintain awkward body postures for extensive periods during their work. These postures include slumped sitting, leaning on one side, bending and twisting, and excessive reaching. Drivers might adopt awkward postures to avoid discomfort caused by a poor ergonomic chair. These positions, combined with an uncomfortable chair, can place mechanical stress upon the spine and its surrounding soft structures and ultimately cause LBP.

LEISURE-TIME PHYSICAL ACTIVITY

Evidence of the contribution of physical activity to the prevention and management of LBP is unclear. Despite the risk of activity-related injuries, some experts [23] found an association between physical activity and a lower risk of musculoskeletal disorders plausible. Randomized trials and epidemiological studies on exercise as a means of strengthening back and/or abdominal muscles and of improving fitness have resulted in only limited evidence of a positive effect on low back morbidity; empiric evidence, in particular, of the long-term effects of exercise is still lacking [24]. Toroptsova et al. [25], in their cross-sectional study of 800 machine-building factory workers, found a significant association between the absence of sports activity and LBP.

In the present study, the engagement in leisure-time physical activity was associated with a lower risk of LBP. We believe this is the first study to show such an association among professional drivers. It is possible that despite inconsistent results in the literature concerning physical activity and LBP, most of the drivers in the current study reported that they walked in their free time, an activity that might have a positive effect on a sedentary occupation.

To date, very few studies have investigated the psychosocial stressing factors. Moreover, psychosocial and ergonomic stressing factors were never studied among urban bus drivers. The results of our study showed that those stressing factors are very common among professional drivers and can contribute to work-related musculoskeletal morbidity. We present here new psychosocial risk factors that need to be considered for developing prevention strategies for LBP, especially among professional bus drivers.

INVERSE RELATIONSHIP BETWEEN LBP AND AGE

One of the less expected results of the present study was the inverse relationship between LBP and the age of the drivers. The most reasonable explanation for this relationship is the so-called healthy worker effect. It is known that bus drivers leave their job due to back problems and adverse work conditions [4].

CONCLUSIONS

The main conclusion to be drawn from this study is that both ergonomic and psychosocial stressing factors as well as lack of sports activity are associated with LBP in professional urban bus drivers. These associations should be further confirmed in prospective studies. However, even at the present stage, LBP prevention strategies such as the transition to comfortable seats, encouragement of sports activities, and organizational changes for reducing work-related stress are needed.

Acknowledgments:
This study was supported by a grant from the Israeli Ministry of Industry, Trade and Labor.

Correspondence:
Dr. D. Alperovitch-Najenson
Dept. of Physical Therapy, Steyer School of Health Professions, Sackler Faculty of Medicine, Tel Aviv University, Ramat Aviv 69978, Israel
Phone: (972-3) 640-5341
Fax: (972-3) 640-5436
email: deboraha@post.tau.ac.il

References

1. Anderson R. The back pain of bus drivers. Prevalence in an urban area of California. *Spine* 1992; 17: 1481-8.
2. Magnusson ML, Pope MH, Wilder DG, Areskoug B. Are occupational drivers at an increased risk for developing musculoskeletal disorders? *Spine* 1996; 21: 710-17.
3. Hulshof CT, Verbeek JH, Braam ITJ, Bovenzi M, van Dijk FJH. Evaluation of an occupational health intervention programme on whole-body vibration in forklift truck drivers: a controlled trial. *Occup Environ Med* 2006; 63: 461-8.
4. Krause N, Ragland DR, Fisher JM, Syme SL. Psychosocial job factors, physical workload, and incidence of work-related spinal injury: a 5-year prospective study of urban transit operators. *Spine* 1998; 23: 2507-16.
5. Chen J-C, Chang W-R, Chang W, Christiani D. Occupational factors associated with low back pain in urban taxi drivers. *Occup Med* 2005; 55: 535-40.
6. Lyons J. Factors contributing to low back pain among professional drivers: a review of current literature and possible ergonomic controls. *Work* 2002; 19: 95-102.
7. Kelsey JL, Hardy RJ. Driving of motor vehicles as a risk factor for acute herniated lumbar intervertebral disc. *Am J Epidemiol* 1975; 102: 63-73.
8. Pope MH, Magnusson M, Wilder DG. Low back pain and whole body vibration. *Clin Orthop Relat Res* 1998; 354: 241-8.
9. Svensson HO, Andersson GBJ. The relationship of low back pain, work

history, work environment, and stress: a retrospective cross-sectional study of 38 to 64 year-old women. *Spine* 1989; 14: 517-22.

10. Kuorinka I, Jonsson B, Kilbom A, et al. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Appl Ergon* 1987; 18: 233-7.
11. Robb MJ, Mansfield NJ. Self-reported musculoskeletal problems amongst professional truck drivers. *Ergonomics* 2007; 50: 814-27.
12. Netterstrøm B, Juel K. Low back trouble among urban bus drivers in Denmark. *Scand J Soc Med* 1989; 17: 203-6.
13. Bigos SJ, Battié MC, Spengler DM, et al. A prospective study of work perceptions and psychosocial factors affecting the report of back injury. *Spine* 1991; 16: 1-6.
14. Bongers PM, de Winter CR, Kompier MA, Hildebrandt VH. Psychosocial factors at work and musculoskeletal disease. *Scand J Work Envrion Health* 1993; 19: 297-312.
15. Bernard BP, ed. Musculoskeletal Disorders and Workplace Factors. 1997 DHHS (NIOSH) Publication No. 97-141. Edited by PHS U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Cincinnati, OH: U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health.
16. Miyamoto M, Shirai Y, Nakayama Y, Gembun Y, Kaneda K. An epidemiologic study of occupational low back pain in truck drivers. *J Nippon Med Sch* 2000; 67: 186-90.
17. Sauter S, Swanson N. An ecological model of musculoskeletal disorders in office work. In: Moon S, Sauter S, eds. Beyond Biomechanics: Psychosocial Aspects of Musculoskeletal Disorders in Office Work. London: Taylor & Francis, 1996: 3-21.
18. Theorell T, Harms-Ringdahl K, Ahlberg-Hulten G, Westin B. Psychosocial job factors and symptoms from the locomotor system: a multicausal analysis. *Scand J Rehabil Med* 1991; 23: 165-73.
19. Nachemson AL. Disc pressure measurements. *Spine* 1981; 6(1): 93-7.
20. Andersson BJ, Ortengren R. Myoelectric back muscle activity during sitting. *Scand J Rehabil Med Suppl* 1974; 3: 73-90.
21. Lis AM, Black KM, Korn H, Nordin M. Association between sitting and occupational LBP. *Eur Spine J* 2007; 6: 283-98.
22. Chen JC, Dennerlein JT, Chang CC, Chang WR, Christiani DC. Seat inclination, use of lumbar support and low-back pain of taxi drivers. *Scand J Work Environ Health* 2005; 31: 258-65.
23. Hildebrandt VH, Bongers PM, Dul J, van Dijk FJ, Kemper HC. The relationship between leisure time, physical activities and musculoskeletal symptoms and disability in worker populations. *Int Arch Occup Environ Health* 2000; 73: 507-18.
24. Videman T, Sarna S, Battié MC, et al. The long-term effects of physical loading and exercise lifestyles on back-related symptoms, disability, and spinal pathology among men. *Spine* 1995; 20: 699-709.
25. Toroptsova NV, Benevolenskaya LI, Karyakin AN, Sergeev IL, Erdesz S. "Cross-sectional" study of low back pain among workers at an industrial enterprise in Russia. *Spine* 1995; 20: 328-32.