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[Original Article]

COMPARISON OF POSTURAL CHANGES AND MUSCLE FATIGUE BETWEEN TWO TYPES OF LUMBAR SUPPORT : A PROSPECTIVE LONGITUDINAL STUDY

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Abstract : Background : Lumbar supports are used in the management of low back pain (LBP). Although various types of lumbar supports are available, insufficient evidence exists regarding their effectiveness. The aim of this study was to investigate the effect of two types of lumbar support on postural change and muscle fatigue in a prospective longitudinal study.

Methods : A total of 144 subjects (9 men and 135 women) with LBP were enrolled in this study. Subjects were divided into 2 groups : a conventional lumbosacral support (LS) group and a wear-type support (SW) group. They filled in questionnaires that included the Short Form 36-Item Health Survey (SF-36), the Roland-Morris Disability Questionnaire (RDQ), and a questionnaire that evaluated the severity of LBP at baseline, 1, 2, and 3 months. The first 40 enrolled subjects were investigated for muscle fatigue and walking efficacy during a gait-loading test, and posture at baseline, 1 month, and 3 months.

Results : The intensity of LBP and the number of days with LBP significantly decreased over time in both groups. The decrease was similar in both groups at each time point. Wearing either support for 3 months did not induce erector spinae muscle fatigue. Furthermore, walking efficacy improved but spinal alignment was not affected by either support. Subjects in the SW group reported that the support was comfortable to wear for long periods, while subjects in the LS group mentioned that the LS relieved LBP by tightly supporting the lower back.

Conclusion : Both types of support reduced mild LBP and improved walking efficiency without causing muscle fatigue.

Key words : Lumbar support, Low back pain, QOL, Walking capacity, Spinal alignment

INTRODUCTION

Low back pain (LBP), one of the most prevalent conditions in the general population, decreases quality of life (QOL) and is associated with significant direct and indirect costs. Various conservative treatments are conducted for LBP, including lumbar support braces that can be used for LBP treatment as well as injury prevention¹⁻⁶⁾. In general, the effects of these braces results from both the restric-

tion of flexion-extension movements and lateral bending⁷⁾ as well as the reduction of intradiscal pressure on the lumbar vertebrae⁸⁾ and the decrease of load on the trunk⁹⁾. However, in spite of the popularity of these supports and the availability of various designs, there is insufficient evidence regarding their effectiveness^{2,6)}. In addition, the relationship between muscle fatigue, muscle activity and low back pain remain an unresolved controversial issue, and a causal relationship between muscle fatigue and

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low back pain have not been found⁷). Furthermore, the effectiveness of lumbar support treatment on back muscles has yet to be fully investigated. The higher level evidence of lumbar support efficacy has not been shown and no type of lumbar support is specifically recommended in LBP guidelines. Few studies have reported on applications of conservative treatment using lumbar support, duration of use, and selection of lumbar support for LBP.

The purpose of this study was to investigate the effects of two types of lumbar supports on postural changes and muscle fatigue.

MATERIALS AND METHODS

Ethics

This study was approved by the ethics committee of our university. Written informed consent was obtained from all subjects prior to participation.

Subjects

This study was a prospective longitudinal study. The recruitment period was from January 4, 2011 to March 31, 2012. Subjects included nurses older than 20 years who worked at one university hospital or three local hospitals in three cities. Inclusion criteria included a LBP rating score (0–10 numerical rating scale : NRS) of 3 or more for the worst LBP intensity at least once a week for the past 3 months. Subjects were excluded if they had lower extremity pain, a history of surgery for lumbar disorders, a psychiatric disorders, or mental disorders.

Experimental Protocol

Subjects were assigned consecutive numbers based on provision of written informed consent in each institution. Subjects were divided into two groups : subjects assigned an odd number wore a

wear-type support (SW : Spinal Underwear, Alcare, Tokyo, Japan), and subjects assigned an even number wore a traditional lumbosacral support (LS : SACRO Vivanurse, Alcare) (Fig. 1). The LS is the most commonly used support and compresses the waist to support the lumbar region. The SW is a new style of support developed to convert uncomfortable compression into comfortable support through tactile stimulation. The SW uses NANO FRONT[®] (Teijin, Osaka, Japan) on the back, a material that stimulates tactile sense as well as affects the erector spinae to promote better posture.

Subjects wore the assigned support for the first month except when in bed and during bathing. For the next 2 months, they wore it only when LBP occurred. The first 40 subjects who enrolled at the university hospital also underwent the gait-loading test described below.

Questionnaire

Subjects filled in a questionnaire at baseline, 1, 2, and 3 months. QOL was evaluated using the Short-Form 36 Health Survey (SF-36) on which a higher score indicates better QOL^{10,11}. Disability was assessed using the Roland-Morris Disability Questionnaire (RDQ) on which a higher score indicates greater disability^{12,13}. All subjects kept a daily diary that included the daily severity of LBP by visual analog scale (VAS : 0–100 mm : 0 mm no pain, 100 mm the worst pain), the number of days that LBP was present, the number of days the lumbar support was worn, and the duration of time (hours) the lumbar support was worn per day for 3 months. At the end of the study, subjects provided feedback on the lumbar support they used via a self-reported questionnaire. The questions evaluated the subject's satisfaction with using a support, desire to use the support after this study when LBP occurred, and specific items related to using a support (compression around the abdomen, relief of pain, willingness to wear a support for a long period, feeling of fatigue while using a support, ability to take part in activities while wearing a support, and trouble associated with wearing a support).

Additional Variables Assessed in 40 Subjects

A gait-loading test, fatigue of erector spinae test, efficiency of walking, and change of posture were assessed in the first 40 subjects who enrolled at the University Hospital.

Gait-loading test

Selected subjects walked on a motorized tread-



Fig. 1. Two types of lumbar support
 a. A wear type support (SW)
 b. A traditional lumbosacral support (LS)

mill (SPR-7020, Sakai Medical, Tokyo, Japan) at 3.0 km/h, at a 5-degree incline for 20 minutes. Instruction was given before the test, and they practiced walking on the treadmill for a few minutes. Mean power frequency (MPF) and physiological cost index (PCI) were measured during the test at registration (baseline), 1 month, and 3 months of wearing the assigned lumbar support.

Erector spinae muscle fatigue

MPF was calculated to investigate erector spinae muscle fatigue. The MPF shows myoelectrical activities that were measured using Holter-type surface electromyography (ME6000, Mega Electronics Ltd., Kuopio, Finland). Measurements were taken at two points on the skin overlying the erector spinae, approximately 3 cm from the midline at the L1-2 (upper) and the L4-5 (lower) vertebrae levels. The MPF at each level was examined during the gait-loading test at baseline, 1 month, and 3 months. Smaller values of MPF indicate muscle fatigue. Time-dependent changes in muscle fatigue under the influence of wearing each lumbar support were compared between groups.

Efficiency of walking

The PCI was calculated to investigate the efficiency of walking¹⁴⁾ using the following formula: heart rate (bpm) during walking—heart rate (bpm) at rest/walking velocity (m/min). Decrease of heart rate following reduction of physical fatigue results in improvement of PCI. Before testing, a heart rate monitor (RS800CX, Polar Electro, Kempele, Finland) was put on each subject's wrist, and a transmitter (WearLink31C transmitter W.I.N.D, Kempele) was attached to the chest. During the gait-loading test, the monitored heart rate was transmitted to a personal computer and the PCI was calculated. Smaller PCI values indicate better walking efficacy.

Change of posture

Sagittal spinal alignment was measured using a Spinal Mouse® (Idiag, Volketswil, Switzerland) in a standing position to assess changes in kyphosis and lordosis angles between thoracic and lumbar vertebrae. By sliding the device along the spinal curvature (C7-S3), sagittal spinal alignment was calculated and displayed on the computer monitor. Measurements were performed three times and the mean angle was calculated.

Statistical analysis

The Mann-Whitney U test was used to com-

pare MPF, RDQ score, SF-36, VAS, and the length of time wearing the lumbar supports between groups. One-way analysis of variance was used to compare PCI and VAS scores between groups and assess changes between groups over time. SPSS (version 17.0; SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Data are presented as proportions and means (\pm SD). P values less than 0.05 were considered statistically significant.

RESULTS

A total of 144 subjects (9 men and 135 women, mean age 39.5 ± 11 , range 22–64 years) were registered. The gait-loading test was performed on 40 subjects (mean age, 33 years in the SW group, 37 years in the LS group). There were no significant differences in gender or age distributions between groups.

Severity of symptoms

VAS scores at baseline were 20.7 ± 16.1 mm in the SW group and 23.2 ± 23.6 mm in the LS group (Table 1). There were no differences in severity of LBP at baseline between groups. The average VAS scores and the days with LBP for 1 month at each time point are shown in Table 1. VAS scores decreased to 17.2 ± 14.0 mm and 20.6 ± 21.4 mm at 1 month, 14.0 ± 13.6 mm and 16.0 ± 20.7 mm at 2 months, and 10.3 ± 13.3 mm and 11.4 ± 14.4 mm at 3 months in the SW group and LS group, respectively. There were no significant differences in VAS scores between groups at any time point. In contrast, with the exception of findings at 1 month, the VAS scores decreased significantly at each time point compared with the baseline in both groups. The days of LBP use were 13.0 ± 9.7 and 12.9 ± 10.4 for the first month, 12.6 ± 11.4 and 10.4 ± 10.6 for the second month, and 9.7 ± 10.8 and 9.6 ± 10.6 for the third month in the SW group and LS group, respectively. The number of days subjects experienced LBP decreased month by month in both groups.

RDQ scores

RDQ scores at baseline were 2.8 ± 3.6 in the SW group and 3.2 ± 3.8 in the LS group. There was no difference in RDQ scores at baseline between the two groups. RDQ scores were 2.8 ± 3.8 and 2.7 ± 2.9 at 1 month, and 2.4 ± 4.3 and 2.6 ± 3.2 at 3 months in the SW group and LS group, respectively. There were no significant differences in RDQ and SF-36 subscale scores between groups at any time point (Table 1).

Table 1. RDQ and SF-36 scores at each time point

	Mean (SD)			Mean (SD)		
	Baseline		<i>p</i>	1 month		<i>p</i>
	SW	LS		SW	LS	
Subject	73	71				
Male : Female	5 ; 68	4 ; 67				
Age	38.6±10.3	40.4±11.7				
intensity of LBP						
Average VAS (mm)	20.7 (16.1)	23.2 (23.6)	0.74	17.2 (14.0)	20.6 (21.4)	0.95
Days of LBP existence				13.0 (9.7)	12.9 (10.4)	0.98
RDQ	2.8 (3.6)	3.2 (3.8)	0.81	2.8 (3.8)	2.7 (2.9)	0.87
SF-36						
Physical functioning	48.3 (9.9)	47.5 (10.3)	0.76	50.1 (7.8)	47.3 (9.2)	0.1
Role physical	47.8 (9.3)	44 (12.0)	0.13	49.3 (8.7)	46.4 (9.7)	0.09
Bodily pain	42.7 (8.3)	40.6 (8.0)	0.28	44.6 (6.8)	43.9 (6.9)	0.99
General health	48.3 (8.6)	48.6 (8.8)	0.82	47.6 (8.7)	48.6 (8.5)	0.51
Vitality	42.1 (8.7)	43.4 (8.0)	0.46	43.3 (8.0)	44.1 (7.6)	0.53
Social functioning	48.0 (9.5)	47.5 (9.4)	0.75	48.3 (9.2)	48.2 (9.0)	0.88
Role emotional	49.3 (8.1)	45.9 (11.3)	0.17	49.9 (7.7)	47.3 (10.7)	0.42
Mental health	46.4 (8.0)	46.8 (7.7)	0.76	47.8 (8.0)	48.0 (8.2)	0.98
	Mean (SD)			Mean (SD)		
	2 month		<i>p</i>	3 month		<i>p</i>
	SW	LS		SW	LS	
intensity of LBP						
Anerage VAS (mm)	14.0 (13.6)	16.0 (20.7)	0.89	10.3 (13.3)	11.4 (14.4)	0.37
Days of LBP existence	12.6 (11.4)	10.4 (10.6)	0.57	9.7 (10.8)	9.6 (10.6)	0.74
RDQ	2.8 (4.1)	0.4 (2.9)	0.87	2.4 (4.3)	2.6 (3.2)	0.53
SF-36						
Physical functioning	49.6 (9.4)	46.9 (11.5)	0.21	50.8 (9.6)	48.0 (10.7)	0.19
Role physical	49.0 (9.4)	46.1 (10.5)	0.19	49.0 (8.3)	47.3 (9.0)	0.4
Bodily pain	44.9 (7.5)	44.9 (6.7)	0.94	44.5 (8.5)	44.5 (8.2)	1
General health	46.8 (8.4)	49.3 (9.1)	0.26	47.6 (10.3)	49.9 (9.0)	0.39
Vitality	43.3 (8.8)	44.5 (6.6)	0.52	42.9 (8.7)	45.0 (8.4)	0.31
Social functioning	48.3 (9.9)	47.3 (8.6)	0.53	48.6 (11.0)	48.4 (8.2)	0.6
Role emotional	50.6 (8.6)	46.9 (10.6)	0.08	50.2 (9.3)	47.9 (8.5)	0.13
Mental health	47.3 (8.7)	48.1 (8.4)	0.83	46.9 (9.8)	48.6 (7.3)	0.69

SF-36 : average of original score (1-100)

Erector spinae muscle fatigue

Changes of MPF at 1 and 3 months were compared with baseline (Fig. 2). The MPF of upper and lower vertebrae levels did not decrease at any point in either group. In addition, there were no significant differences in the changes of MPF between groups.

Efficiency of walking

Changes of PCI during 20 minutes of the gait-loading test are shown in Fig. 3. There was no dif-

ference of PCI between groups at each time point. In both groups, PCI during walking significantly decreased at 1 and 3 months compared with baseline ($p < 0.05$). In the LS group, PCI was lower than in the SW group at 1 and 3 months ($p < 0.05$).

Change of posture

Sagittal spinal alignments in the thoracic kyphosis and lumbar lordosis are shown in Fig. 4. The angle of kyphosis in the thoracic vertebrae changed from 41.2 ± 9.0 at baseline to 39.8 ± 8.3 at 3 months in the SW group, and from 42.4 ± 11.1 at baseline to

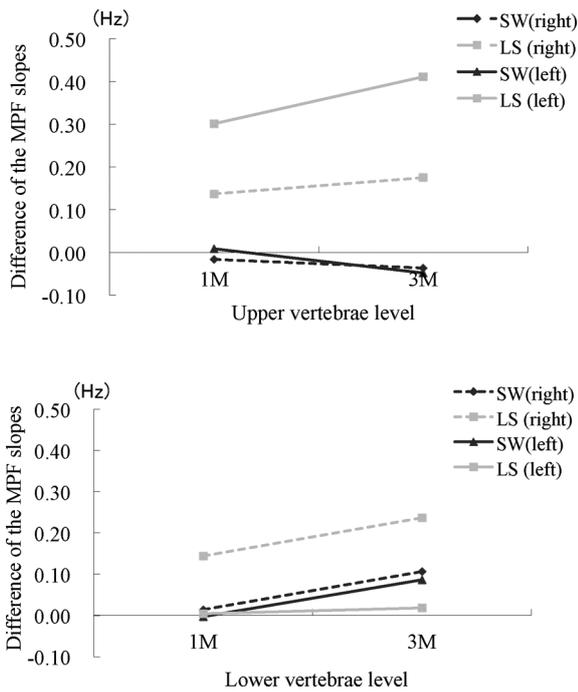


Fig. 2. Change of MPF
Mean power frequency (MPF) was measured at 1 month (a) and 3 months (b).
At each point, muscle fatigue did not occur.
There were no significant differences in MPF at each time point between the two groups.

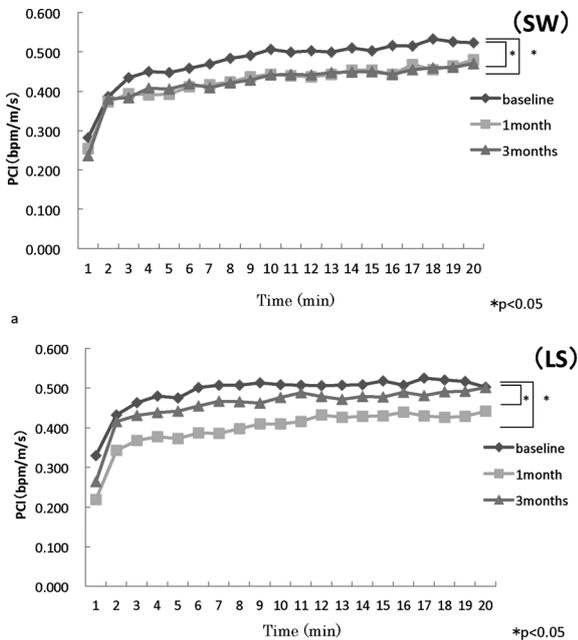


Fig. 3. Change of PCI
In the SW group (a) and LS group (b), PCI significantly improved at 1 and 3 months compared with baseline ($p < 0.05$).

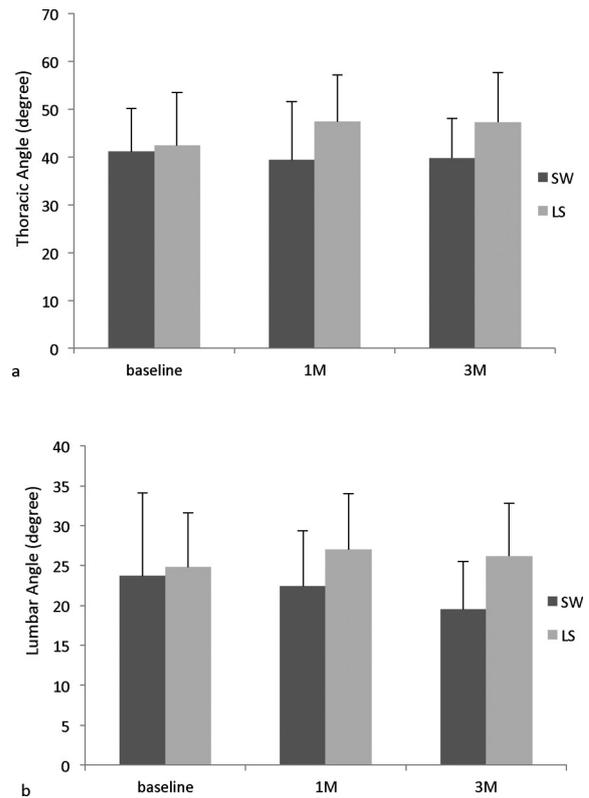


Fig. 4. Change of alignment
Kyphosis of thoracic vertebrae (a) and lordosis of lumbar vertebrae (b) are shown. There were no significant differences between the two groups.

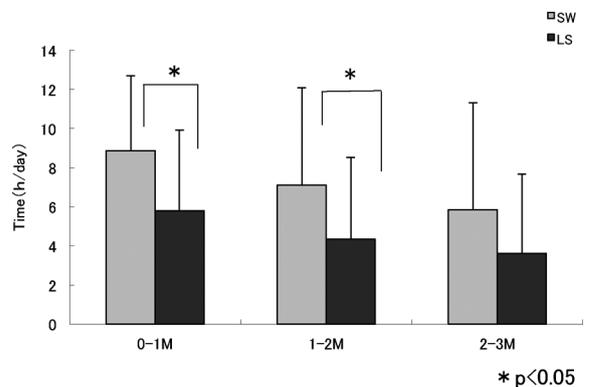


Fig. 5. Duration of each support
In the SW group, length of time wearing the support was significantly longer for two months compared with that of the LS group ($p < 0.05$).

47.3±10.3 at 3 months in the LS group. The angle of lordosis in the lumbar vertebrae also changed from 23.7±10.4 at baseline to 19.5±6.0 at 3 months in the SW group, and from 24.8±6.8 at baseline to 26.2±6.6 at 3 months in the LS group. No significant differences were found in the thoracic and lumbar angles between groups. These results indicate that neither SW nor LS affected spinal alignment.

Table 2. Feedback from subjects on each lumbar support

	SW (<i>n</i> =45) <i>n</i> (%)	LS (<i>n</i> =40) <i>n</i> (%)
a. relief of LBP	10 (22.2)	27 (67.5)
b. easy to move	17 (37.8)	19 (47.5)
c. less compression	20 (44.4)	1 (2.5)
d. able to wear for a long time	34 (75.6)	9 (22.5)
e. not troublesome	18 (40.0)	5 (25.0)
f. not fatigue due to support	17 (37.8)	9 (22.5)

Duration of wearing supports

In both groups, the length of time wearing the lumbar support decreased at each time point compared with the first month. The duration of wearing SW was significantly longer than that of LS from 1 to 1 month and from 1 to 2 months ($p < 0.05$) (Fig. 5).

Feedback on lumbar supports (Table 2)

Thirty-nine of 45 subjects (86.7%) in the SW group and 34 of 40 subjects (85%) in the LS group were satisfied with their respective support. In addition, 30 (66.7%) subjects in the SW group and 34 (85%) in the LS group wanted to wear a support, should LBP occur, after this study. Subjects in the SW group felt less compression around the abdomen (44.4%), would keep wearing the support for long periods (75.6%), and had relief of pain (22.2%). Subjects in the LS group had relief of pain (67.5%), less compression (2.5%), and wanted to wear a support for long periods, if needed (22.5%).

DISCUSSION

In the present study, we investigated the effects of two types of lumbar support on LBP, disability due to LBP, changes of muscle fatigue, and posture. In both groups, VAS scores improved and the number of days subjects experienced LBP decreased longitudinally, however there were no significant differences between groups at any time point. These results suggest that the new style of support, SW, had a similar effect as the LS, a conventional lumbar support to relieve LBP. Although LBP was reduced after wearing both supports, results of the RDQ and SF-36 scores suggest that disability over 3 months was not affected by LBP with the help of either lumbar support, and no significant differences in these scores were observed between groups. Subjects in the present study were able to continue working as nurses despite having LBP. In addition, their LBP

was mild, and disability regarding activities of daily living was not severe. Therefore, the use of lumbar supports might not to improve disability due to LBP in this study. In addition, even if the duration of wearing SW was longer than that of wearing LS, the degree of relieving LBP was similar in both groups. Based on this study, it is not clear whether the duration of wearing the SW support influenced pain relief or if subjects were not comfortable wearing the LS support.

According to the changes of MPF, erector spinae muscle fatigue was not induced with either support over 3 months. One study reported that, endurance of back muscles was reduced in adolescent idiopathic scoliosis patients who underwent brace treatment at a 20 year follow-up period¹⁵. Long-term use of lumbar support has therefore been considered to lead to disuse atrophy of back muscles due to restriction of lumbar movement. In our previous study, muscle fatigue was not increased 6 months after wearing a corset of a similar type to the traditional lumbar support used in this study¹⁶. Neither lumbar support in the present study led to the disuse of lower back muscles.

Walking efficacy and changes in posture were also investigated. PCI improved at 1 month, and the effect lasted for 3 months with either lumbar support. These results suggest that walking efficacy improved after wearing either lumbar support. In particular, the walking efficacy of subjects wearing LS support improved greatly compared to those wearing the SW support. Curvatures such as lordosis, flat, or kyphosis are assumed to be the main factors impacting lumbar muscle activation. The most important radiographic parameters of sagittal balance of the spine in the upright posture are well defined¹⁷⁻²⁰; however, few reports present normal physiological values. Moreover, it is well established that a physiological upright standing posture is reached in a different way for each person with unique and individual patterns of spinopelvic balance and sagittal alignment¹⁷. Standard values of thoracic and lumbar alignments have not yet been determined. Gender differences are expected in sagittal lumbar-spinal alignment because of different pelvic shapes. There are no gender differences regarding the lumbar lordotic angle, sacral slope, or pelvic tilt in the standing position²¹. Lumbar lordosis and thoracic kyphosis are independent of gender²². There is great variability of spinal alignment in the normal population, with a wide range of normal values in adults²³. One study showed that total lordosis was significantly less in LBP patients com-

pared with non-LBP patients and was not age- or sex-related in either group²⁴. The angles of thoracic kyphosis and lumbar lordosis in the healthy persons are reported to be $38.3 \pm 7.2^\circ$ and $17.4 \pm 10.3^\circ$, respectively²⁵. This study did not assess whether or how much posture would be improved in people with pathological conditions compared with healthy people. One of the limitations of this study is that evidence regarding the relationship between walking efficacy and the posture changes was insufficient.

Subjects were satisfied using the assessed support, and the benefits of these two types of support were different. Subjects in the SW group wore the support longer, and they considered that SW was comfortable to wear for a long time. According to the patient's needs for LBP relief, particularly in terms of working hours, the SW was comfortable for long periods. In contrast to the traditional lumbar support, LS relieved LBP by supporting the lower back tightly, but it was not comfortable for long periods. Feedback from subjects regarding both lumbar supports was positive. All of the subjects in this study were nurses who could continue to work even though they had LBP. Therefore, their LBP was not severe but the lumbar support might be of use while working. According to the subjects' feedback, SW might be preferable for workers with LBP, because of its lower compression around the abdomen and being more comfortable to wear. However, the effect of both supports on more severe LBP has not been investigated and this is a limitation of this study. Another limitation of this study was that we checked the duration of wearing the support by a self-reported diary; therefore, data on wearing the supports might not be reliable. Although the duration of wearing either support in the present study varied, this matter is similar to actual clinical situations. Furthermore, interventions using a lumbar support might impact LBP improvement. The subjects were workers in the medical institutions as a nurse, therefore, subjects in this study did not receive any medications and only used a lumbar support in this study for pain relief. A control support (which is made by only a basement material) was not used due to ethical problems. Furthermore, the time period of this study did not represent a natural course of LBP. Although results of this study did not exclude a placebo effect seen with a lumbar support, the SW, which provides less compression around the abdomen, might be an alternative support source to the traditional LS support in patients with mild LBP. Furthermore studies and longer

follow up are needed to demonstrate the effect of different lumbar supports on patients with severe LBP.

In conclusion, the prospective longitudinal study was conducted for workers. Both types of support had an effect on reducing LBP and improving walking efficiency. In addition, muscle fatigue was not induced by either support. Lumbar support is useful for mild LBP.

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