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Original

Effects of a wearable type lumbosacral support for low back pain among hospital workers: A randomized controlled trial

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Abstract: Objective: To examine the effects of a new wearable type of lumbosacral support on low back pain. **Methods:** A total of 121 healthcare workers participated in this study. They were randomly allocated into the experimental and control groups and the former wore the support with signals of compression on the back by poor posture for the first 3 months. The control group remained on a waiting list for the first 3 months. Medical history, musculoskeletal symptoms, feeling in good posture, sleep habits, psychological distress, Roland-Morris Disability Questionnaire, and Somatosensory Amplification Scale (SSAS) were evaluated. The range of motion (ROM) in the shoulder and hip joints as well as spinal alignment were evaluated. Our primary concern was the difference in the change of low back pain measured by visual analog scale (VAS) between the two groups. **Results:** A total of 54 participants in the experimental and 53 participants in the control groups were analyzed. VAS and SSAS scores as well as lumbar spinal ROM in the experimental group significantly decreased. Low back pain (OR=0.401, 95% CI=0.168-0.954) and neck pain in the experimental group (OR=0.198, 95% CI=0.052-0.748) significantly decreased. **Conclusions:** The new lumbar support reduced VAS and SSAS scores, lumbar spinal ROM, low back pain, and neck pain. This new type of lumbar support reduced low back pain among healthcare workers.
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Key words: Healthcare workers, Low back pain, Lumbar support, Posture, Somatosensory Amplification Scale, Spinal alignment

Introduction

Work-related musculoskeletal disorders are a major contribution to the cost of work-related illness in developed countries[1,2]. Low back pain has influences on quality of life, work absenteeism, and medical expenses[3], including in nurses[4]. Working people (25-60 years) are affected by low back pain at least once in their lifetime[5].

Various ergonomic aids are marketed for the prevention of low back pain. Lumbar supports are frequently used to prevent low back pain among workers with a reduced trunk motion for flexion-extension and lateral bending[6,7]. Furthermore, it reduces intradiscal pressure on the lumbar vertebrae[8] as well as load on the trunk[9]. A history of low back pain was a strong predictor for the incidence of new episodes of low back pain[10]. Homecare workers with frequent episodes of low back pain reported an adherence rate of 61% to 81% with lumbar supports and 45% decreases in pain intensity when using lumbar supports[11]. However, their effectiveness is still unclear[7] and no type of lumbar support is specifically recommended for low back pain[12].

Nurses have a risk of low back pain from being in awkward postures, carrying and repositioning patients, prolonged standing, and working without sufficient breaks[13]. Flexion, rotation, and awkward positions of the lumbar spine have a strong association with low back pain[14]. Lifting in-bed patients is a major risk factor of low back pain among nurses[13]. These situations are limited not only to nurses but also to other hospital workers.

A neutral posture is composed of an amalgamation of

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Fig. 1. Appearance of Spinal Underwear.
Asterisk: Textile fabrics for stimulating the back while in poor posture.

the position of multiple joints, bones, and muscles along the longitudinal axis of the body with equilibrium[15]. However, continuous poor posture, defined as increased forward head, greater thoracic kyphosis, and a more anterior shoulder position, can lead to musculoskeletal imbalances and pain, which might cause stresses on ligaments and intervertebral discs of the lumbar region[16]. Furthermore, poor posture affects scapular kinematics, which causes shoulder problems[17].

Low back pain is defined as a "bio-psycho-socially induced disease"[18]. Feelings of helplessness and hopelessness are important predictors of the onset and persistence of psychosomatic disorders[19]. Working status and subjective economic hardship were significantly associated with new onset of low back pain for survivors of the Great East Japan Earthquake[20,21]. Poor sleep is known to cause a range of physiological and psychological effects[22]. Postures associated with dominance and power affect how people experience pain[23]. Low back pain could be affected by multiple factors.

This study aimed to evaluate a new wearable type of lumbosacral support on the musculoskeletal symptoms, postural changes, psychological distress, sleep disturbance, somatosensory amplification, and range of motion (ROM) in the major joints.

Methods

Participants

The protocols of this study were approved by the institutional review board of Takeda General Hospital (approval number: H25-004) and all participants consented to join this study. The recruitment period was set from July 26 to October 30, 2013, and this study was conducted from November 19, 2013 to July 20, 2014. A total of 121 workers (5 males and 116 females) at Takeda General Hospital participated in this study and were 20 years old or older. They included nurses (98, 81%), care workers (9, 7.4%), medical assistants (11, 9.1%), and physical therapists (3, 2.5%). Inclusion criteria was a low back pain rating score (0-10 numerical rating scale: NRS) of 3 or more for the worst low back pain at least once a week for the previous 3 months at the recruitment period[24]. Exclusion criteria were as follows: (1) sensory disturbance in lower extremities; (2) history of surgery for lumbar disorders; (3) psychiatric disorders; and (4) mental disorders.

Randomization and masking

Participants were assigned consecutive numbers upon recruitment based on consent forms. They were randomly allocated into the experimental and control groups in a 1:1 ratio according to block randomization with a randomly selected block size of 4 or 6, generated by R3.0.1.

Experimental protocol

The wearable type of lumbosacral support (Spinal Underwear, Alcare, Tokyo, Japan) has been developed to correct posture using signals of compression on the skin of the back from poor posture. It uses NANO FRONT® (Teijin, Osaka, Japan) on the back (gray area, Fig. 1), which stimulates a tactile sense on the skin of the back while in poor posture. These stimuli can affect the erector spinae muscles to correct into a better posture[24]. The experimental group wore the support for the first 3 months except bathing and sleeping. Participants in the control group remained on a waiting list and were informed that they would wear the Spinal Underwear after 3 months had passed in the same manner.

Measurement and Outcome

Evaluations were performed at the beginning and end of the program by the same blinded examiner for both groups. This questionnaire included medical history, subjective musculoskeletal symptoms (shoulder discomfort, knee pain, feeling numbness (not sensory disturbance), shoulder pain, neck pain, back pain, pain in extremities, and headache)[20,21], sleep habits (Athens Insomnia Scale)[25], psychological distress (K6)[26], Roland-Morris Disability Questionnaire (RDQ, Japanese version)[27], and Somatosensory Amplification Scale (SSAS)[28]. Subjective "feeling in good posture" was also inquired to evaluate postural changes of participants. ROM, including the shoulder joints in a standing position (forward flexion, external rotation with the arm at the side), the hip joints in a supine position (straight leg raising test, flexion, internal rotation), were evaluated with a goniometer and standing

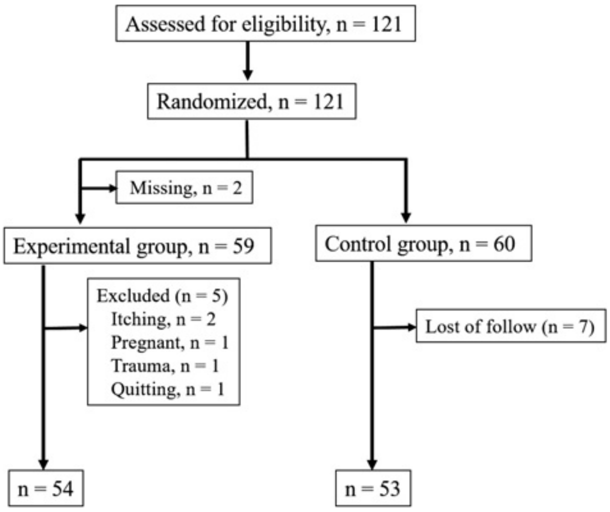

Fig. 2. Selection of study participants.

sagittal spinal alignment (flexion, neutral, and extension) with a Spinal Mouse® (Idiag, Volketswil, Switzerland). The spinal curvature (C7-S3) was measured 3 times and the mean angle was calculated[12]. Susceptibility of sleep disturbance was defined as greater than or equal to 6/24 points on the Athens Insomnia Scale. Psychological distress was defined as greater than or equal to 10/24 points on K6. Psychosomatic disease was suspected to be greater than or equal to 31/50 points on SSAS. Only low back pain was measured using a visual analog scale (VAS) ranging from 0 cm for no pain to 10 cm for unbearable pain[29] from immediately before starting this study to the final follow-up. Age, gender, height, body weight, sleep disturbance, psychological distress, and somatosensory amplification were considered as confounding factors. Our primary outcome was determined to be the difference in the change of low back pain measured by VAS between the two groups. We also considered the following as a secondary outcome: Presence of subjective musculoskeletal symptoms, feeling in good posture, Athens Insomnia Scale, K6, RDQ, SSAS, and ROM of the shoulder joints, hip joints, and spine. The compliance of wearing the Spinal Underwear was checked by a diary in which participants had to write every day.

Statistical analysis

All statistical analyses were planned in an intention-to-treat manner. For the continuous variable, analysis of variance for repeated measures was used to estimate the intergroup difference over time. When the P value of the interaction term of allocation (x) time was <0.05, we considered the difference as statistically significant. As effect size, we calculated partial η^2 using type III sum of squares. No covariate was put into the regression model. For the binary variable (presence of subjective musculoskeletal symptoms), for which we used a logistic regression model, allocation and baseline information of symptoms present were put into as predictive variables. All analyses were performed using R3.0.1. and P value of <0.05 was set for statistical significance. No adjustments for multi-hypothesis tests were conducted.

Results

One hundred and twenty-one participants were randomly assigned to the experimental (n=61) and control groups (n=60) (Fig. 2). Baseline characteristics of participants (N=121) immediately after recruitment were shown in Table 1. Participants with severe low back pain (n=79, VAS ≧3) had significantly higher VAS (p=0.0005), RDQ scores (p<0.0001), rate of feeling numbness (p=0.011), and the right shoulder flexion (p=0.015) as compared with those having moderate low back pain (n=40, VAS <3). There were no significant differences in the other criteria. There was no significant difference between the experimental and control groups in every criterion, including VAS, immediately after randomization (data not shown). In the experimental group, 2 participants were excluded because of a misunderstanding in their group. Furthermore, in the same group, 5 participants were lost due to itching (n=2), pregnant (n=1), trauma (n=1), and quitting (n=1). In the waiting control group (n=60), 7 participants were lost. A total of 54 participants in the experimental group (2 males and 52 females) and 53 participants in the control group (1 male and 52 females) were analyzed in the final follow-up (Fig. 2). There was no significant difference in the spinal alignment. VAS scores at baseline characteristics of the experimental (n=54) and control groups (n=53) were homogenous at the beginning of this protocol (Table 2). However, VAS was significantly lower in the experimental group as compared with the control group (p=0.038) because of the two missing participants. The experimental group exhibited significant improvement over time as compared with the control group with regard to VAS (F=4.53, df=1; 105, p=0.036, partial η^2=0.04) and SSAS scores (F=5.72, df=1; 105, p=0.019, partial η^2=0.05). The lumbar spinal ROM in the experimental group significantly decreased as compared with the control group (F=4.15, df=1; 103, p=0.044, partial η^2=0.04) (Table 3). There were no significant differences between the two groups with regard to the remaining variables. With regard to subjective symptoms, low back pain (OR=0.401, 95% CI=0.168-0.954, p=0.039) and neck pain (OR=0.198, 95% CI=0.052-0.748, p=0.017) in the experimental group significantly decreased as compared with the control group (Table 4). There were no significant differences between the two groups with regard to the remaining musculoskeletal symptoms.

Table 1. Baseline characteristics of the participants

	Low back pain		P
	Moderate (n=40)	Severe (n=79)	
Age	44.2±10.4	44.7±9.8	0.798
Gender (Female, %)	38 (95%)	78 (98.7%)	0.261
Height	158.3±6.2	157.8±5.4	0.637
Body weight	56.0±9.4	57.3±9.6	0.481
VAS	2.00±1.77	3.43±2.20	0.0005
RDQ	0.98±1.44	3.25±2.91	<0.0001
K6	4.2±3.3	3.9±3.8	0.775
Athens	5.1±2.8	4.8±2.8	0.530
SSAS	28.6±5.6	29.0±5.8	0.734
Feeling in good posture	2 (5%)	8 (10.1%)	0.492
Shoulder discomfort	25 (62.5%)	52 (65.8%)	0.839
Knee pain	11 (27.5%)	20 (25.3%)	0.827
Numbness	1 (2.5%)	15 (19%)	0.011
Shoulder pain	12 (30%)	12 (15.2%)	0.089
Neck pain	9 (22.5%)	13 (32.5%)	0.459
Back pain	8 (20%)	10 (12.7%)	0.294
Pain in extremities	3 (7.5%)	6 (7.6%)	1.000
Headache	7 (17.5%)	23 (29.1%)	0.188
Spinal Mouse®			
Flexion (Th)	50.8±11.9	47.6±20.8	0.366
Flexion (L)	38.2±16.5	42.1±19.3	0.281
Flexion (S)	42.8±20.5	43.1±16.2	0.928
Extension (Th)	21.8±19.6	22.1±21.5	0.950
Extension (L)	–37.0±11.7	–32.6±11.4	0.052
Extension (S)	–2.1±10.2	–2.2±8.4	0.967
Thoracic spinal ROM	29.1±18.2	25.4±31.3	0.495
Lumbar spinal ROM	74.6±20.6	74.5±18.4	0.966
Sacral spinal ROM	45.1±20.3	45.3±17.2	0.953
Neutral (Th)	39.1±13.0	34.0±25.8	0.239
Neutral (L)	–21.8±10.1	–19.1±11.4	0.212
Neutral (S)	6.8±8.4	10.2±41.9	0.612
Flexion-Neutral (Th)	11.4±14.8	13.6±36.1	0.708
Flexion-Neutral (L)	60.1±15.8	60.9±14.4	0.800
Flexion-Neutral (S)	36.2±18.8	33.0±45.5	0.676
Neutral-Extension (Th)	17.7±19.3	11.9±33.3	0.318
Neutral-Extension (L)	14.9±9.7	13.4±9.6	0.419
Neutral-Extension (S)	8.8±10.2	12.4±41.2	0.599
Range of motion			
Rt. SLR*	72.1±12.1	73.3±11.6	0.619
Rt. Hip flexion	120.0±9.9	119.1±9.4	0.631
Rt. Hip internal rotation	43.4±11.6	41.7±10.5	0.438
Rt. Shoulder flexion	160.9±14.8	166.7±10.4	0.015
Rt. Shoulder external rotation	69.6±13.7	71.3±15.9	0.575
Lt. SLR*	71.0±14.1	73.2±10.8	0.348
Lt. Hip flexion	120.6±7.9	118.4±8.0	0.152
Lt. Hip internal rotation	43.1±12.7	42.6±11.5	0.81
Lt. Shoulder flexion	162.1±14.7	164.1±16.4	0.506
Lt. Shoulder external rotation	69.8±14.2	71.4±13.1	0.56

SLR*: Straight leg raising test

Table 2. Baseline characteristics of the participants after the randomization

	Experimental group (n=54)	Control group (n=53)	P
Age	44.7±10.0	44.7±9.6	0.994
Gender (Female, %)	52/54	52/53	>0.99
Height	157.7±5.7	158.6±5.3	0.414
Body weight	57.1±10.2	57.0±9.0	0.940
VAS	2.48±2.09	3.35±2.16	0.038
RDQ	2.26±2.44	2.83±3.17	0.298
K6	3.9±3.8	4.3±3.2	0.549
Athens	4.6±2.3	5.2±3.2	0.268
SSAS	30.0±5.9	28.0±5.0	0.063
Feeling in good posture	5 (9.26%)	5 (9.43%)	>0.99
Low back pain	35 (64.8%)	36 (67.9%)	0.838
Shoulder discomfort	33 (61.1%)	37 (68.5%)	0.418
Knee pain	12 (22.2%)	16 (30.2%)	0.385
Numbness	8 (14.8%)	8 (15.1%)	>0.99
Shoulder pain	13 (24.1%)	11 (20.8%)	0.817
Neck pain	11 (20.4%)	9 (17%)	0.805
Back pain	9 (16.7%)	6 (11.3%)	0.579
Pain in extremities	3 (5.56%)	5 (9.43%)	0.489
Headache	10 (18.5%)	15 (28.3%)	0.260
Spinal Mouse®			
Flexion (Th)	49.7±16.6	50.3±10.5	0.808
Flexion (L)	42.7±18.0	39.5±18.2	0.352
Flexion (S)	41.0±17.7	44.0±17.7	0.383
Extension (Th)	21.9±21.8	22.4±21.0	0.898
Extension (L)	–34.0±10.8	–34.1±12.3	0.980
Extension (S)	–2.0±9.0	–2.1±7.6	0.962
Thoracic spinal ROM	27.9±27.4	28.0±21.1	0.988
Lumbar spinal ROM	76.5±20.9	73.0±16.9	0.353
Sacral spinal ROM	43.1±18.9	46.3±17.8	0.380
Neutral (Th)	33.0±29.8	39.3±11.1	0.151
Neutral (L)	–18.6±10.2	–20.5±11.5	0.362
Neutral (S)	12.0±50.3	6.2±9.5	0.412
Flexion-Neutral (Th)	16.7±37.2	10.8±12.3	0.269
Flexion-Neutral (L)	61.0±16.6	59.8±12.8	0.669
Flexion-Neutral (S)	29.1±54.5	37.9±16.0	0.262
Neutral-Extension (Th)	11.4±37.8	16.9±19.8	0.348
Neutral-Extension (L)	15.4±9.2	13.3±9.5	0.269
Neutral-Extension (S)	14.0±49.7	8.3±7.6	0.420
Range of motion			
Rt. SLR*	73.1±11.9	73.3±12.2	0.947
Rt. Hip flexion	120.4±8.6	120.0±9.7	0.835
Rt. Hip internal rotation	42.2±10.8	42.6±10.2	0.837
Rt. Shoulder flexion	166.2±11.2	164.5±11.2	0.442
Rt. Shoulder external rotation	70.5±13.9	71.0±17.0	0.849
Lt. SLR*	71.5±12.2	72.9±12.7	0.549
Lt. Hip flexion	118.7±7.4	120.8±7.4	0.156
Lt. Hip internal rotation	42.7±11.7	42.6±12.3	0.985
Lt. Shoulder flexion	166.1±11.4	161.8±19.3	0.167
Lt. Shoulder external rotation	72.1±14.0	70.2±12.7	0.455

SLR*: Straight leg raising test

Table 3. Changes after the intervention

	Experimental group (n=54)	Control group (n=53)	P
	Mean, SD	Mean, SD	
Height	–0.0, 0.5	–0.1, 0.5	0.794
Body weight	0.2, 1.3	0.1, 1.0	0.440
VAS	–1.1, 1.8	–0.3, 1.9	0.036
RDQ	–0.6, 2.3	–0.5, 3.0	0.815
K6	–0.37, 3.26	–0.70, 2.62	0.568
Athens	–0.57, 2.69	–1.55, 2.85	0.072
SSAS	–2.80, 5.39	–0.53, 4.35	0.019
Spinal Mouse®			
Flexion (Th)	–0.9, 18.4	–8.3, 33.2	0.160
Flexion (L)	–17.3, 19.4	–11.1, 19.3	0.103
Flexion (S)	9.2, 21.2	6.1, 16.3	0.395
Extension (Th)	5.0, 20.1	0.1, 18.8	0.195
Extension (L)	–6.5, 12.5	–6.5, 12.1	0.990
Extension (S)	6.5, 11.0	5.1, 10.1	0.503
Thoracic spinal ROM	–5.9, 29.9	–6.8, 37.0	0.892
Lumbar spinal ROM	–10.6, 19.1	–3.1, 18.9	0.044
Sacral spinal ROM	2.6, 19.1	1.2, 19.7	0.742
Neutral (Th)	1.7, 33.5	–2.3, 13.0	0.424
Neutral (L)	–8.4, 13.6	–7.8, 11.4	0.812
Neutral (S)	–0.4, 50.8	6.2, 9.0	0.355
Flexion-Neutral (Th)	–2.3, 39.2	–5.7, 38.5	0.648
Flexion-Neutral (L)	–8.8, 17.0	–3.3, 18.7	0.117
Flexion-Neutral (S)	9.5, 57.4	–0.4, 16.7	0.233
Neutral-Extension (Th)	–3.8, 40.8	–2.9, 20.6	0.884
Neutral-Extension (L)	–1.8, 11.1	–0.7, 12.3	0.646
Neutral-Extension (S)	–6.9, 47.8	1.0, 8.9	0.242
Range of motion			
Rt. SLR*	–1.1, 12.6	–1.7, 12.7	0.811
Rt. Hip flexion	–2.2, 11.5	0.6, 9.4	0.174
Rt. Hip internal rotation	–6.3, 11.5	–5.3, 9.6	0.621
Rt. Shoulder flexion	0.6, 11.9	–2.0, 15.5	0.326
Rt. Shoulder external rotation	0.6, 10.6	–4.5, 20.0	0.097
Lt. SLR*	–0.2, 12.7	–1.9, 13.2	0.498
Lt. Hip flexion	–1.9, 10.9	–2.0, 7.6	0.943
Lt. Hip internal rotation	–4.1, 11.2	–4.7, 11.2	0.768
Lt. Shoulder flexion	–2.5, 12.4	0.4, 17.5	0.321
Lt. Shoulder external rotation	0.5, 10.3	–2.6, 10.9	0.132

SLR*: Straight leg raising test
SD: Standard deviation

Discussion

The 12-month prevalence of low back pain has been estimated to be from 15% to 64% in developed countries[30]. Healthcare settings had high rates of work-related illness, such as low back pain, workplace violence, shift work, needle stick injuries, high physical work load, and job stress[31]. Low back pain is one of the main problems affecting quality of life and work productivity as well as absenteeism pattern and disabilities in nursing[4]. These situations are similar to those in other hospital workers besides nurses. About 78% hospital workers have experienced low back pain and over 47% of them had difficulty

Table 4. Changes of musculoskeletal symptoms

	OR	95% CI	P
Feeling in good posture	2.94	0.729, 11.80	0.130
Low back pain	0.401	0.168, 0.954	0.039
Shoulder discomfort	0.425	0.153, 1.180	0.102
Knee pain	0.688	0.205, 2.310	0.545
Numbness	1.32	0.295, 5.940	0.713
Shoulder pain	0.554	0.183, 1.680	0.296
Neck pain	0.198	0.052, 0.748	0.017
Back pain	0.492	0.149, 1.630	0.245
Pain in extremities	0.378	0.086, 1.670	0.199
Headache	0.884	0.309, 2.530	0.818

OR: Odds ratio

in their work in our pilot survey of this study prior to the recruiting period (data not shown).

Mechanical, psychological, social factors play an important role in symptom onset and maintenance of non-specific low back pain[32]. Among mechanical factors, posture is considered to be a risk factor for non-specific low back pain[32]. Poor posture is a common finding in patients with a musculoskeletal complaint[33]. Postural balance is controlled by coordination of multiple segments in the kinetic chain from foot to head[15]. Because low back pain originates from various factors, ROM in major joints, such as the hip and shoulder, and spinal alignment was measured in this study. However, there were no significant differences in the spinal ROM and ROM in the hip between participants with severe or moderate low back pain with baseline characteristics after the recruitment period (Table 1). Participants had severe low back pain at the recruitment period but there remained a possibility to reduce the pain while waiting for the start of this study. The right shoulder flexion in the severe low back pain group had a significant increase, which could be explained by most of them being right handed, and they make lordosis to reduce low back pain, which results in internal rotation of the right scapula[17]. This scapular kinematics seem to influence the shoulder ROM. There were no significant differences in the spinal motion, expect for the lumbar ROM, and ROM in the hip and shoulder between the experimental and control groups at the final follow-up. This seems to be explained by a small sample size and follow-up periods were limited. Not only the sagittal but also the coronal alignment should be considered in future analyses.

Lumbopelvic complex has ROM of 110° (40° in the lumbar spine and 70° in the hip joint) and participants with low back pain had more lumbar segment motion than the pelvis during forward bending of the trunk as compared with those without low back pain[34]. A repetitive and sustained flexed posture may lead to impaired spinal muscle control[35]. Thus, greater lumbar motion can induce overloading of the lumbar spine and consequently low back pain[36]. The decrease in the lumbar ROM at the final follow-up may have a positive effect on the experimental group.

Low back pain is influenced by several factors[32]. Indices of depression and somatization had strong correlations with functional limitation by low back pain[34]. It is comprehensible that participants with severe low back pain had significantly higher VAS scores at baseline characteristics at the recruitment period. However, there were no significant differences of psychological distress (K6) or Athens Insomnia Scale, which have a relationship with depression, between participants with severe and moderate low back pain. Somatization seems to affect those with severe low back pain, which could explain an increase of subjective numbness on them. VAS scores in the experimental group were significantly lower as compared with those in the control group because two participants failed to start. However, VAS scores in the experimental group significantly decreased at the final follow-up. Furthermore, these effects had continued after 3 months after completion in the experimental group (data not shown). The Spinal Underwear had an effect of reducing low back pain and a decrease of lumbar ROM seems to be continuing after taking it off. SSAS scores significantly decreased in the experimental group and they seem to have a relationship with low back pain. Further study is needed to clarify these phenomena.

At the beginning of this study, the rates of subjective feeling of good posture were estimated to increase in the experimental group, because the Spinal Underwear stimulates tactile sense on the skin of the back while in poor postures. However, there was no significant difference between the two groups. As the height in the experimental group was not changed at the final follow-up, effects of the Spinal Underwear seemed to be limited to restriction of the lumbar ROM. Follow-up periods were short and the sample size was quite small, which could make it difficult to detect the difference.

With regard to musculoskeletal symptoms, neck pain as well as low back pain significantly decreased in the experimental group. This phenomenon may also prove that musculoskeletal symptoms are influenced by several factors, such as postures and somatization[34].

Previous studies have used various devices for postural monitoring having a problem with the trade-off between portability and accuracy of measurement[37-39]. The provision of constant postural feedback via audio feedback, such as the Spinal Underwear, decreased low back pain[40]. However, the Spinal Underwear has the advantage of keeping good posture through daily unconscious training without interference.

This study has several limitations. First, this study adopted prospective, randomized, open, blinded-endpoint method. Preferably, sham procedure (same underwear without NANO FRONT®) should be prepared. However, it was difficult to manufacture them. Further study with a strict blinded manner is needed. Second, ROM was measured only in the hip and shoulder. The other joints, such as the ankle, knee, and cervical ROM could be measured in further studies to prove the correlation between poor posture and low back pain. Third, evaluation of psychological factors was limited. Fourth, musculoskeletal symptoms were ambiguous. Fifth, the follow-up rate was not high. At last, we looked at the symptoms of low back pain, but the underlying pathology was not assessed.

Conclusion

This study demonstrated that a new wearable type lumbar support (Spinal Underwear) reduced VAS and SSAS scores, lumbar spinal ROM, low back pain, and neck pain. This lumbar support has a positive effect on reducing low back pain among healthcare workers.

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