J. Phys. Ther. Sci. 32: 680–685, 2020

The Journal of Physical Therapy Science

Original Article

Relationship between low back pain and lumbar and hip joint movement in desk workers

Takaaki Nishimura, RPT, MS[1, 2], Ryo Miyachi, RPT, PhD[3)*]

[1)] *Nanto City Visiting Nursing Station: 938 Inami, Nanto-shi, Toyama 932-0211, Japan*
[2)] *Department of Physical Therapy, Graduate Course of Rehabilitation Science, Division of Health Sciences, Graduate School of Medical Sciences, Kanazawa University, Japan*
[3)] *Department of Physical Therapy, Faculty of Health Sciences, Kyoto Tachibana University, Japan*

Abstract. [Purpose] The study aimed to determine the relationship between low back pain and lumbar and hip movement in desk workers with chronic non-specific low back pain, in order to obtain basic data regarding measures for preventing low back pain in desk workers. [Participants and Methods] The study included 10 desk workers (all female, age: 47.1 ± 6.0 years). The following measurements were recorded: numerical rating scale score for pain assessment at the time of maximum forward and backward bending of the trunk while standing, and the amount of movement of the trunk and the lumbar and hip joint. The ratio of the lumbar and hip joint movements during maximum forward and backward bending of the trunk was calculated. [Results] For maximum forward and backward bending of the trunk, a positive correlation between the numerical rating scale score and the ratio of movement for the lumbar and a negative correlation with that of the hip joint were noted. [Conclusion] Moving the hip joint while suppressing excessive lumbar movement is one of the measures for preventing low back pain in desk workers.
Key words: Desk workers, Non-specific low back pain, Ratio of movements

(This article was submitted May 31, 2020, and was accepted Jul. 17, 2020)

INTRODUCTION

It is estimated that 70–80% of the world's population will experience low back pain at least once, of which 85% is non-specific low back pain[1, 2]. Non-specific low back pain has been reported to have no apparent cause[2] and does not correlate with findings on an X-ray or nuclear magnetic resonance imaging with clinical symptoms[3]. It is believed that exacerbation of back pain leads to a decrease in productivity due to difficulties in employment and has a significant socio-economic impact[4]. Among workers, those who spend 80% of their working hours in a sitting position are defined as desk workers (DWs)[5], and DWs are said to be more likely to develop low back pain due to their prolonged sitting posture[6, 7]. In recent years, it has been reported that the prevalence of low back pain in DWs has increased with the development of Information Technology equipment[8]. Therefore, the prevention of low back pain in DWs is an important socio-economic issue.

To evaluate low back pain, the amount of lumbar and hip joint movements during maximum forward and backward bending of the trunk in the standing position are often evaluated[9–11]. A characteristic of the movement of people with low back pain is the increased ratio of lumbar movement to the ratio of hip joint movement in maximum forward and backward bending of the trunk in the standing position[9, 11, 12]. Therefore, one of the factors for the appearance of lower back pain was considered to be the influence of hypermobility of the lumbar during trunk movement.

In the sitting posture with the trunk flexed, it has been reported that flexion relaxation phenomenon appears in the erector spinae[13], and support of the lumbar is secured by soft tissues such as the posterior spinal ligament[14]. In other words, the sitting posture of DWs is thought to be maintained for a long time owing to the stiffness of non-contracted tissues such as

*Corresponding author. Ryo Miyachi (E-mail: takaaki07_nishimura05@yahoo.co.jp)

ligaments. It is assumed that the sustained elongation load on the non-contracted tissue increases the ratio of lumbar movement during trunk movement, which may lead to low back pain. In addition, it has been reported that hip joint movement is closely related to the lumbar movement[15, 16], and that low back pain is associated with excessive mobility of the lumbar as well as decreased mobility of the hip joint[17]. Therefore, it is possible that the lumbar pelvic rhythm is imbalanced even in DWs with low back pain. However, there are no reports on the relationship between low back pain and the ratio of lumbar and hip joint movements during maximum forward and backward bending of the trunk in the standing position in DWs. If the relationship between low back pain, lumbar, and hip movements during trunk movement is determined, it may help in considering measures to prevent back pain in DWs with low back pain. The aim of this study was to determine the relationship between low back pain, lumbar, and hip movements in DWs with chronic non-specific low back pain to obtain basic data for measures to prevent low back pain in DWs.

PARTICIPANTS AND METHODS

The participants were 10 DWs with chronic nonspecific low back pain (all female, age: 47.1 ± 6.0 years, height: 158.4 ± 5.5 cm, weight: 55.0 ± 6.1 kg). The contribution of hip range of motion during trunk movement is higher in female than in male[18]. Since hip joint movement is associated with lumbar movement[15, 16], then low back pain is more likely to be related to trunk movements as females were selected for this study. Females were also selected to unify the participants. The participants did not have any specific orthopedic diseases of the lumbar and hip joint caused by low back pain and did not have any apparent limitation in the range of motion of the hip joint (flexion angle: 120 ± 3.3°, extension angle: 14 ± 3.9°). The criteria for chronic low back pain in this study were those with chronic low back pain for more than 12 weeks[19, 20]. DWs were defined as workers who spend 80% of their working hours in the seated position[5]. As for ethical considerations, this study was explained and written consent was obtained from all participants. The study was approved by the Ethics Committee of the Nanto Home Visit Nursing Station (approval number: 2019.NHS.3).

The study design was cross-sectional. The task was to measure the maximum forward and backward bending of the trunk in a standing position, at which time photographs and video filming were taken. Also, the inertial sensor tilt angle (TSND151, ATR-Promotions, Kyoto, Japan) was measured. Reflection markers for photographic and video filming were placed at six locations: the seventh cervical vertebrae, the right anterior superior iliac spine (ASIS), the right posterior superior iliac spine (PSIS), the third sacral vertebrae, the right greater trochanter, and the right epicondylus lateralis ossis femoris (Fig. 1). An inertial sensor was installed at the third lumbar vertebrae and set up in the acceleration range of 8G, an angular velocity range of ± 1,000 dps, a sampling interval of 10 ms, and an average number of 1 of samples using the receiving software (Sensor Controller, ATR-Promotions, Kyoto, Japan). A digital video camera (HDC-TM45, Panasonic Corporation, Kadoma, Japan) was set up 3 m to the right side of the participants.

The video recording was performed during the task, and photographs were taken at rest standing positions and during maximum forward and backward bending of the trunk. Before the task, the participants were tasked with the measurement task, following which they practiced the forward and backward bending of the trunk in the standing position one for each. Measurements were performed at rest standing for 2 sec, followed by forward bending of the trunk, and held in the final position for 2 sec. After that, the participants returned to rest standing and held rest standing for 2 sec. The participants performed this forward and backward bending of the trunk twice. For the measurements, inertial sensors and video recordings were synchronized. Numerical Rating Scale (NRS)[21] was used as an index of the intensity of low back pain during maximum forward and backward bending of the trunk, and interviewed the participants after each trial. The NRS was used as a self-rating system for pain, which requires a pain score on a scale of 11 from 0 to 10, with 0 being no pain and 10 being the worst pain imaginable[21]. The NRS has been used as an index of the intensity of low back pain[22, 23] and also validated and reliable[21, 24]. Therefore, the NRS was used as an index of the intensity of low back pain in this study.

For the data analysis, the image analysis software Image J[25] was used to calculate the amount of trunk and hip joint movements during maximum forward and backward bending of the trunk in the standing position based on the reflection markers (Fig. 2). The amount of trunk movement was determined as the difference between the trunk tilt angle in the rest standing (the angle at which the line connecting the seventh cervical vertebrae and the third sacral vertebrae intersects the perpendicular line from the floor, hereafter referred to as the trunk tilt angle), while trunk tilt angle was determined during maximum forward and backward bending of the trunk (Fig. 2). The amount of hip joint movement was defined as the difference between pelvic tilt angle at rest standing (the angle at which the line connecting the ASIS and PSIS intersects the line connecting the right greater trochanter and right epicondylus lateralis ossis femoris, hereafter referred to as pelvic tilt angle) and pelvic tilt angle during maximum forward and backward bending of the trunk (Fig. 2). The amount of trunk and hip joint movements were calculated from the mean values of the two trials, respectively. This value was then used as the representative value for each task. Inertial sensor tilt angle was set as the difference between maximum forward and backward bending of the trunk and rest standing. Inertial sensor tilt angle was calculated as the average angle for each 2 sec during the rest standing and maximum forward and backward bending of the trunk. The mean of the two trials in each task was then used as a representative value. The amount of lumbar movement was the difference between the amount of inertial sensor tilt angle and the amount of hip joint movement during maximum forward and backward bending of the trunk. The ratio of the lumbar and hip joint movements to the amount of trunk movement (the amount of lumbar and hip joint movements / the amount of

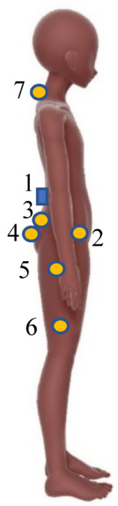

Fig. 1. Location of reflection markers and inertial sensor.
1: Third lumbar vertebrae (inertial sensor).
2: Right anterior superior iliac spine (reflection marker).
3: Right posterior superior iliac spine (reflection marker).
4: Third sacral vertebrae (reflection marker).
5: Right greater trochanter (reflection marker).
6: Right epicondylus lateralis ossis femoris (reflection marker).
7: Seventh cervical vertebrae (reflection marker).

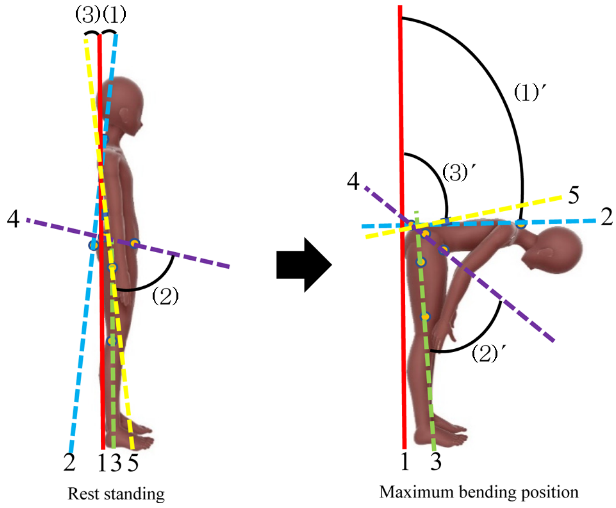

Fig. 2. Each baseline and the amount of movement in each region.
1: Perpendicular lines from the floor.
2: Line connecting the seventh cervical vertebrae and third sacral vertebrae.
3: Line connecting the right greater trochanter and right epicondylus lateralis ossis femoris.
4: Line connecting the ASIS (right anterior superior iliac spine) and PSIS (right posterior superior iliac spine).
5: Inertial sensor tilt lines.
(1): Trunk tilt angle in rest standing.
(1)′: Trunk tilt angle in maximum bending position.
(2): Pelvic tilt angle in rest standing.
(2)′: Pelvic tilt angle in maximum bending position.
(3): Angle between the inertial sensor tilt angle and the perpendicular line from the floor in rest standing.
(3)′: Angle between the inertial sensor tilt angle and the perpendicular line from the floor in maximum bending position.
| (1)−(1)′ |: The amount of trunk movement.
| (2)−(2)′ |: The amount of hip joint movement.
| (3)−(3)′ |−| (2)−(2)′ |: The amount of lumbar movement.
(| (3)−(3)′ |−| (2)−(2)′ |) / | (1)−(1)′ | ×100: The ratio of the lumbar movement.
(| (2)−(2)′ | / | (1)−(1)′ |)×100: The ratio of the hip joint movement.

movement of trunk ×100) was calculated. This value was then used as the ratio of the lumbar and hip joint movements during maximum forward and backward bending of the trunk. The NRS was defined as the mean of the 2 trials during maximum forward and backward bending of the trunk as representative values for each task.

Statistical analysis was performed using EZR (Easy R, Saitama Medical Center, Jichi Medical University, Saitama, Japan)[26]. The median (interquartile range) of each value was calculated after testing the normality of the NRS and ratio of the lumbar and hip joint movements during maximum forward and backward bending of the trunk using the Shapiro-Wilk normality test. Following this, the relationship between the NRS, ratio of the lumbar and hip joint movements during forward and backward bending of the trunk was assessed using the Spearman's rank correlation coefficient. The level of significance was set at 0.05.

RESULTS

NRS and the amount of lumbar and hip joint movements during maximum forward and backward bending of the trunk are shown in Table 1. The NRS during maximal forward and backward bending of the trunk was comparable. During maximal forward bending of the trunk, ratio of the hip joint movement tended to be greater than the ratio of lumbar movement. During maximal backward bending of the trunk, the ratio of the lumbar movement tended to be greater than the ratio of hip joint movement.

Table 1. NRS and the ratios of lumbar and hip joint movements during maximum forward and backward bending of the trunk

	Maximum forward bending of the trunk	Maximum backward bending of the trunk
NRS	3 (2.3–4.8)	3 (2.3–4.8)
The ratio of lumbar movement (%)	31.8 (14.0–34.2)	72.9 (61.0–83.8)
The ratio of hip joint movement (%)	56.3 (42.5–58.2)	36.7 (27.0–57.6)

Values are expressed as median (interquartile range).
NRS: Numerical Rating Scale (0: no pain, 10: maximum pain).

Table 2. Correlation coefficients between NRS, and the ratio of lumbar and hip joint movements during maximum forward and backward bending of the trunk

	Ratio of lumbar movement	Ratio of hip joint movement
NRS in maximum forward bending of the trunk	0.76*	−0.66*
NRS in maximum backward bending of the trunk	0.65*	−0.65*

*: Correlation with NRS ($p<0.05$).
NRS: Numerical Rating Scale (0: no pain, 10: maximum pain).

Table 2 shows the relationship between the NRS, ratio of the lumbar, and hip joint movements during maximum forward and backward bending of the trunk. A positive correlation (rs=0.76, p=0.01) was found between NRS and ratio of lumbar movement, and a negative correlation (rs=−0.66, p=0.04) was found between the NRS and ratio of hip joint movement during maximum forward bending of the trunk. A positive correlation (rs=0.65, p=0.04) was found between the NRS and ratio of lumbar movement, and a negative correlation (rs=−0.65, p=0.04) was found between the NRS and ratio of hip joint movement during maximum backward bending of the trunk.

DISCUSSION

In this study, the relationship between low back pain, lumbar, and the hip joint movements of DWs with chronic non-specific low back pain was examined. The results of this study showed a positive correlation between low back pain and the ratio of lumbar movement and a negative correlation between low back pain and ratio of hip joint movement during maximum forward and backward bending of the trunk. It has been reported that chronic nonspecific low back pain is, in part, due to the structural vulnerability of the lumbar region[27)], and that sustained load from habitual exercise patterns in daily life can lead to tissue micro-instability[28)]. It has also been reported that sitting with the trunk flexed for a long period of time causes thinning of the lumbar soft tissues due to gradual elongation of lumbar soft tissues, which impairs the stability of the spine support mechanism[29)] and decreases the rigidity of the lumbar spine in the anteroposterior direction[30)]. It is said that excessive mobility of the lumbar spine stimulates the pain receptors and causes low back pain[31)]. It has also been reported that hip joint movement is closely related to lumbar movement[15, 16)] and that low back pain is associated with excessive mobility of the lumbar as well as decreased mobility of the hip joint[17)]. During trunk exercise, a decrease in the amount of hip joint movement during maximum forward bending of the trunk was caused by excessive mobility of the lumbar spine due to low back pain[32)]. In the present study, participants with strong low back pain may have been less stable in the lumbar spine due to thinning and micro-instability of the lumbar soft tissue compared to those with weakness. As a result, it is thought that participants with strong low back pain move excessively in the lumbar during maximum forward and backward bending of the trunk, and the hip joint movement is relatively small. However, in the present study, it was not possible to determine whether the excessive mobility of the lumbar and the decreased mobility of the hip joint were caused by low back pain, or whether the low back pain was caused by the excessive mobility of the lumbar and the decreased mobility of the hip joint. Therefore, it is necessary to examine the causal relationship between low back pain and excessive mobility of the lumbar or decreased mobility of the hip joint in the future.

The first limitation of this study was the small number of participants (n=10). Therefore, it is necessary to increase the number of participants in the future to investigate the relationship between low back pain and the ratio of lumbar or hip joint movements in DWs. Second, only the final positions of the forward and backward bending of the trunk were measured. Therefore, it is necessary to examine the relationship between the ratio of lumbar and hip joint movements and low back pain and muscle activity during the course of exercise such as trunk forward bending every 20°. Finally, only one camera was used in this study, so only the posture of the sagittal plane was analyzed. It is necessary to examine the relationship between low back pain and the ratio of lumbar and hip joint movements in the frontal and horizontal planes using a three-dimensional motion analysis system.

In conclusion, the aim of this study was to determine the relationship between low back pain, lumbar, and the hip movements in DWs with chronic non-specific low back pain to obtain basic data for measures to prevent low back pain in DWs. The results of the present study showed that low back pain was related to the ratio of the lumbar and hip joint movements during maximum forward and backward bending of the trunk as a characteristic of trunk movements in the standing position in DWs with low back pain. It is also considered important to move the hip joint while suppressing excessive lumbar movement as one of the measures to prevent back pain in DWs. In the future, the number of participants to examine the characteristics of trunk movements in DWs with low back pain has to be increased.

Funding

This work was supported by JSPS KAKENHI grant number JP19K24181.

Conflicts of interest

The authors declare no conflicts of interest.

REFERENCES

1) Andersson GB: Epidemiological features of chronic low-back pain. Lancet, 1999, 354: 581–585. [Medline] [CrossRef]
2) Chou R, Qaseem A, Snow V, et al. Clinical Efficacy Assessment Subcommittee of the American College of Physicians, American College of Physicians, American Pain Society Low Back Pain Guidelines Panel: Diagnosis and treatment of low back pain: a joint clinical practice guideline from the American College of Physicians and the American Pain Society. Ann Intern Med, 2007, 147: 478–491. [Medline] [CrossRef]
3) Jarvik JG, Deyo RA: Diagnostic evaluation of low back pain with emphasis on imaging. Ann Intern Med, 2002, 137: 586–597. [Medline] [CrossRef]
4) Kim W, Jin YS, Lee CS, et al.: Influence of knee pain and low back pain on the quality of life in adults older than 50 years of age. PM R, 2015, 7: 955–961. [Medline] [CrossRef]
5) Spyropoulos P, Papathanasiou G, Georgoudis G, et al.: Prevalence of low back pain in Greek public office workers. Pain Physician, 2007, 10: 651–659. [Medline]
6) Cho CY, Hwang YS, Cherng RJ: Musculoskeletal symptoms and associated risk factors among office workers with high workload computer use. J Manipulative Physiol Ther, 2012, 35: 534–540. [Medline] [CrossRef]
7) Subramanian S, Arun B: Risk factor analysis in sedentary office workers with low back pain. J. Chalmeda Anand Rao Inst. Med. Sci, 2017, 13: 15–18.
8) Collins JD, O'Sullivan LW: Musculoskeletal disorder prevalence and psychosocial risk exposures by age and gender in a cohort of office based employees in two academic institutions. Int J Ind Ergon, 2015, 46: 85–97. [CrossRef]
9) Porter JL, Wilkinson A: Lumbar-hip flexion motion. A comparative study between asymptomatic and chronic low back pain in 18- to 36-year-old men. Spine, 1997, 22: 1508–1513, discussion 1513–1514. [Medline] [CrossRef]
10) Esola MA, McClure PW, Fitzgerald GK, et al.: Analysis of lumbar spine and hip motion during forward bending in subjects with and without a history of low back pain. Spine, 1996, 21: 71–78. [Medline] [CrossRef]
11) Tojima M, Torii S: Changes in lumbopelvic rhythm during trunk extension in adolescent soccer players. Gait Posture, 2017, 52: 72–75. [Medline] [CrossRef]
12) Nelson JM, Walmsley RP, Stevenson JM: Relative lumbar and pelvic motion during loaded spinal flexion/extension. Spine, 1995, 20: 199–204. [Medline] [CrossRef]
13) Callaghan JP, Dunk NM: Examination of the flexion relaxation phenomenon in erector spinae muscles during short duration slumped sitting. Clin Biomech (Bristol, Avon), 2002, 17: 353–360. [Medline] [CrossRef]
14) Floyd WF, Silver PH: The function of the erectores spinae muscles in certain movements and postures in man. J Physiol, 1955, 129: 184–203. [Medline] [CrossRef]
15) Tully EA, Wagh P, Galea MP: Lumbofemoral rhythm during hip flexion in young adults and children. Spine, 2002, 27: E432–E440. [Medline] [CrossRef]
16) Kuo YL, Tully EA, Galea MP: Lumbofemoral rhythm during active hip flexion in standing in healthy older adults. Man Ther, 2010, 15: 88–92. [Medline] [CrossRef]
17) Mellin G: Chronic low back pain in men 54–63 years of age. Correlations of physical measurements with the degree of trouble and progress after treatment. Spine, 1986, 11: 421–426. [Medline] [CrossRef]
18) Kienbacher T, Paul B, Habenicht R, et al.: Age and gender related neuromuscular changes in trunk flexion-extension. J Neuroeng Rehabil, 2015, 12: 3. [Medline] [CrossRef]
19) Ferreira ML, Ferreira PH, Latimer J, et al.: Comparison of general exercise, motor control exercise and spinal manipulative therapy for chronic low back pain: a randomized trial. Pain, 2007, 131: 31–37. [Medline] [CrossRef]
20) Kofotolis N, Kellis E, Vlachopoulos SP, et al.: Effects of Pilates and trunk strengthening exercises on health-related quality of life in women with chronic low back pain. J Back Musculoskeletal Rehabil, 2016, 29: 649–659. [Medline] [CrossRef]
21) Jensen MP, Turner JA, Romano JM, et al.: Comparative reliability and validity of chronic pain intensity measures. Pain, 1999, 83: 157–162. [Medline] [CrossRef]
22) Moseley GL: Joining forces—Combining cognition-targeted motor control training with group or individual pain physiology education: a successful treatment for chronic low back pain. J Manual Manip Ther, 2003, 11: 88–94. [CrossRef]
23) Ryan CG, Gray HG, Newton M, et al.: Pain biology education and exercise classes compared to pain biology education alone for individuals with chronic low back pain: a pilot randomised controlled trial. Man Ther, 2010, 15: 382–387. [Medline] [CrossRef]
24) Ostelo RW, de Vet HC: Clinically important outcomes in low back pain. Best Pract Res Clin Rheumatol, 2005, 19: 593–607. [Medline] [CrossRef]
25) Abramoff MD, Magelhaes PJ, Ram SJ: Image processing with ImageJ. Biophoton Int, 2004, 11: 36–42.
26) Kanda Y: Investigation of the freely available easy-to-use software 'EZR' for medical statistics. Bone Marrow Transplant, 2013, 48: 452–458. [Medline] [CrossRef]

27) Taguchi T: Low back pain in young and middle-aged people. Japan Med Assoc J, 2003, 46: 417–423.
28) Sahrmann S, Azevedo DC, Dillen LV: Diagnosis and treatment of movement system impairment syndromes. Braz J Phys Ther, 2017, 21: 391–399. [Medline] [CrossRef]
29) McGill SM, Brown S: Creep response of the lumbar spine to prolonged full flexion. Clin Biomech (Bristol, Avon), 1992, 7: 43–46. [Medline] [CrossRef]
30) Schultz AB, Warwick DN, Berkson MH, et al.: Mechanical properties of human lumbar spine lotion segments-part 1: responses in flexion, extension, lateral bending, and torsion. J Biomech Eng, 1979, 101: 46–52. [CrossRef]
31) Norris CM: Spinal stabilization. Physiotherapy, 1995, 81: 59–79, 127–147. [CrossRef]
32) Biering-Sørensen F: Physical measurements as risk indicators for low-back trouble over a one-year period. Spine, 1984, 9: 106–119. [Medline] [CrossRef]