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Original article

Predictors of pain intensity and Oswestry Disability Index in prolonged standing service workers with nonspecific chronic low back pain subclassified as active extension pattern

Ui-jae Hwang[a], Oh-yun Kwon[b,*], Sung-hoon Jung[a], Sun-hee Ahn[a], Hyun-a Kim[a]

[a] 234 Maeji-ri, Heungeop-Myeon, Wonju, Kangwon-Do, 220-710, Department of Physical Therapy, Graduate School, Yonsei University, Wonju, South Korea
[b] 234 Maeji-ri, Heungeop-Myeon, Wonju, Kangwon-Do, 220-710, Department of Physical Therapy, College of Health Science, Laboratory of Kinetic Ergocise Based on Movement Analysis, Yonsei University, Wonju, South Korea

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ABSTRACT

Background: Because patients with nonspecific chronic low back pain (NSCLBP) are heterogeneous, subgrouping patients with NSCLBP might clarify the research findings. NSCLBP in the direction of extension movement, namely active extension pattern (AEP), is common during prolonged standing.

Objective: Predictors of pain intensity and dysfunction were determined in prolonged standing service workers (PSSWs) with NSCLBP subclassified as AEP in the motor impairment subgroup.

Methods: Variables were measured using questionnaires including a visual analog scale (VAS), the Oswestry Disability Index (ODI), Borg Rating of Perceived Exertion (RPE) Scale, and Korean Occupational Stress Scale (KOSS). Postural assessment was performed by measuring pelvic anterior tilting angle (PATA). The smart KEMA measurement system was used to evaluate hip flexion, hip extension (HE), and knee flexion range of motion (ROM), as well as hip extensor strength, hip abductor strength (HArS), hip external rotator strength (HERrS), hip internal rotator strength, knee extensor strength, and knee flexor strength, and lumbopelvic stability (LS) in 78 PSSWs with NSCLBP subclassified as AEP.

Results: In prediction models, HArS, LS, PATA, KOSS and HE ROM accounted for 40.1% of the variance in the VAS ($p < 0.05$); predictors of dysfunction included the HERrS and age, which accounted for 11.9% of the variance in the ODI ($p < 0.05$) in multiple regression models when using a stepwise selection procedure.

Conclusions: The present results indicate that HArS and HERrS, LS, PATA, KOSS, HE ROM and age should be considered for evaluating and predicting NSCLBP subclassified as AEP in PSSWs, and when designing interventions.

1. Introduction

Low back pain (LBP) is a highly prevalent and costly musculoskeletal pain syndrome (Koes et al., 2006; Van Tulder and Koes, 2006). LBP is the primary cause of activity limitation and accounts for one-third of all worker compensation claims (Abenhaim et al., 2000).

Many occupations in service sectors require employees to stand (Messing et al., 2008). Epidemiological studies have shown that standing occupations are associated with LBP development (Andersen et al., 2007; Roelen et al., 2007; Shabat et al., 2005; Tissot et al., 2009). For example, service workers in a theme park work in a standing posture for 60–70 h per week with no access to seating (Messing et al., 2005).

LBP is a potentially disabling condition with a complex etiology that may initially result from biomechanical factors, but can be compounded by various psychosocial and occupational risk factors (Borenstein, 2001; Chou et al., 2007). The link theory proposes that the lower extremity kinetic chain functions as one unit, with alterations occurring anywhere within that unit affecting the whole (Nicholas, 1977; Biering-Sørensen, 1984; Fairbank et al., 1984; Mierau et al., 1989; Salminen et al., 1993). Biomechanically, the hip extensors and abductors play a major role in gait, helping to transfer force from the lower extremities to the pelvis during upright activities (Gottschalk et al., 1989; Nelson-Wong and Callaghan, 2010). LBP affects lumbopelvic stability (LS)

* Corresponding author. Address: 234 Maeji-ri, Heungeop-Myeon, Wonju, Kangwon-Do, 220-710, Laboratory of Kinetic Ergocise based on Movement Analysis, Department of Physical, Therapy, Graduate School, Yonsei University, Wonju, South Korea.

E-mail addresses: hwangu33@nate.com (U.-j. Hwang), kwonoy@yonsei.ac.kr, kwonoy1117@gmail.com (O.-y. Kwon), movt_architect@daum.net (S.-h. Jung), tjsgml001@naver.com (S.-h. Ahn), pthyun66@gmail.com (H.-a. Kim).

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(Costa et al., 2009; Liddle et al., 2004) and is associated with lumbar lordosis not only in the hip joint but also in the lumbopelvis (Adams and Hutton, 1980; Dunlop et al., 1984; Shirazi-Adl, 1991). In addition, psychological factors can increase the burden of LBP (Linton, 2000; Zusman, 2002).

Although LBP in prolonged standing workers has various clinical antecedents, in previous studies, ergonomic and questionnaire surveys on fatigue and discomfort in prolonged standing service workers (PSSWs) have been conducted to investigate the risk of LBP (Andersen et al., 2007; Roelen et al., 2007; Shabat et al., 2005; Tissot et al., 2009).

In addition, 75–85% of cases are classified as nonspecific chronic low back pain (NSCLBP), with no evidence of pathoanatomical abnormality. In previous studies, NSCLBP was tentatively subclassified based on movement and motor control impairments (O'Sullivan, 2005; Sahrmann, 2002). Due to a lack of success in defining subgroups to design effective treatments for NSCLBP, further studies focused on establishing classification systems distinguishing subgroups of LBP (Leboeuf-Yde et al., 1997; Leboeuf-Yde and Manniche, 2001; Borkan et al., 1998). Classification of subgroups is necessary for effective NSCLBP intervention guidelines due to the "wash-out effect", where the findings for one subgroup are "washed out" by opposite findings in another subgroup (Rose, 1989).

Thus far, research data have been based on clinical interpretations of movement patterns rather than quantification of strength, flexibility, or posture. Furthermore, by reference to posture, mobility, strength, LS, and psychosocial factors that influence pain intensity, and by application of the Oswestry Disability Index (ODI) to PSSWs with NSCLBP, a specific subgroup based on the O'Sullivan classification (O'Sullivan, 2000; O'Sullivan, 2004). Because the standing posture generates lumbar extension, the present study focused on PSSWs with NSCLBP subclassified as active extension pattern (AEP). The extent to which posture, range of motion (ROM), strength, LS, and psychosocial factors are associated with visual analog scale (VAS) and ODI scores in PSSWs with NSCLBP (subgroup: AEP) was determined.

2. Materials and methods

2.1. Participants

Participants were recruited using a questionnaire to confirm their experience of LBP as PSSWs in a theme park. Among 172 service employees of the theme park, 124 with NSCLBP were included in the present study (Fig. 1). The study participants were assessed and subclassified by two blinded physiotherapists (O'Sullivan, 2000; O'Sullivan, 2004). The 124 subjects with NSCLBP presenting with clinical signs of motor control impairment were subclassified based on the O'Sullivan classification (O'Sullivan, 2000; O'Sullivan, 2004). Seventy-eight subjects with NSCLBP subclassified as AEP (by two blinded physiotherapists) were selected for the study (Table 2). The inclusion/exclusion criteria and a summary of the clinical features of AEP are shown in Table 1. The study protocol was approved by the Yonsei University Wonju Institutional Review Board. Prior to testing, the investigators explained the entire procedure, and all subjects voluntarily provided informed consent.

2.2. Instrumentation

2.2.1. Palpation meter (PALM)

The PALM device (Performance Attainment Associates, St. Paul, MN, USA) was used to measure pelvic anterior tilting angle (PATA) in the standing position. The examiner held the device with both hands and the caliper tips were used to palpate the pelvic bony landmarks (Azevedo et al., 2014). The degree of deviation from the horizontal plane was read from the inclinometer.

2.2.2. Smart KEMA measurement system

The Smart KEMA measurement system (Factorial Holdings Co., Ltd., Seoul, Korea) consists of motion, pressure, tension sensors, and application. Data measured by sensors were transferred to a tablet via Bluetooth and analyzed using the application.

The motion sensor was used to measure ROM for passive hip flexion (HF), hip extension (HE), and knee flexion (KF). Pressure and motion sensors were used to measure LS. The tension sensor was used to measure isometric strength at an initial belt tension of 3 kgf (Kim et al., 2017). The force signals measured from the maximal voluntary isometric contraction included hip extensor strength (HErS), hip abductor strength (HArS), hip external rotator strength (HERrS), hip internal rotator strength (HIRrS), knee extensor strength (KErS), and knee flexor strength (KFrS).

2.2.3. Procedures

Subjects were evaluated at the work conditioning center of the theme park. Subjects were instructed to complete a VAS and several questionnaires including the ODI, Borg Rating of Perceived Exertion (RPE) Scale, and Korean Occupational Stress Scale (KOSS). For postural assessment, PATA was measured followed by measurements of ROM, LS, and strength.

2.3. Outcome measures

2.3.1. Questionnaire

In the current study, a VAS for measuring LBP intensity and the Korean version of the ODI (Kim et al., 2005) to measure dysfunction were the dependent variables. Subjects completed the Borg RPE Scale to measure exertion due to work activities and rate their self-perception (Hwang et al., 2017). The KOSS was used to measure occupational stress (Cho et al., 2008).

2.3.2. PATA

The subjects assumed a standing position, with their feet aligned with their shoulders, and were asked to look at a fixed point straight ahead to control posture sway. The subjects kept their arms crossed over the chest while the examiner palpated the anterior superior iliac spine and posterior superior iliac spine (Azevedo et al., 2014). After marking both anatomical landmarks, the examiner positioned the caliper tips of the PALM device against the marks and the PATA was recorded (Azevedo et al., 2014).

2.3.3. ROM measurement

For HF ROM, a strap with a motion sensor was placed on the thigh between the greater trochanter and knee joint. The examiner maintained lumbar lordotic curvature with one hand and flexed the leg twice with the other hand to reach passive end range of HF (Fig. 2).

For HE ROM, measurements were taken with subjects in a prone position. During passive HE, the pelvis was stabilized by manual pressure. Simultaneously, the ipsilateral lower leg was moved twice to the end range of HE. A strap with a motion sensor was placed on the thigh between the greater trochanter and knee joint (Fig. 2).

For KF ROM, a strap with a motion sensor was placed on the ankle above the lateral malleolus. During passive KF in the prone position, the pelvis was stabilized by manual pressure from one of the examiner's hands and the knee was flexed twice with the other hand to reach passive end range of KF (Fig. 2).

The average values from both sides were calculated.

2.3.4. LS measurement

The subject flexed the hip and knee to 90° while in the supine position. Ipsilateral hip and knee extensions were performed to maintain abdominal pressure without the leg or foot touching a supporting surface. The pressure sensor was set to 40 mmHg and placed below the lordotic curvature of the spine between S1 and L1 with the hip and knee

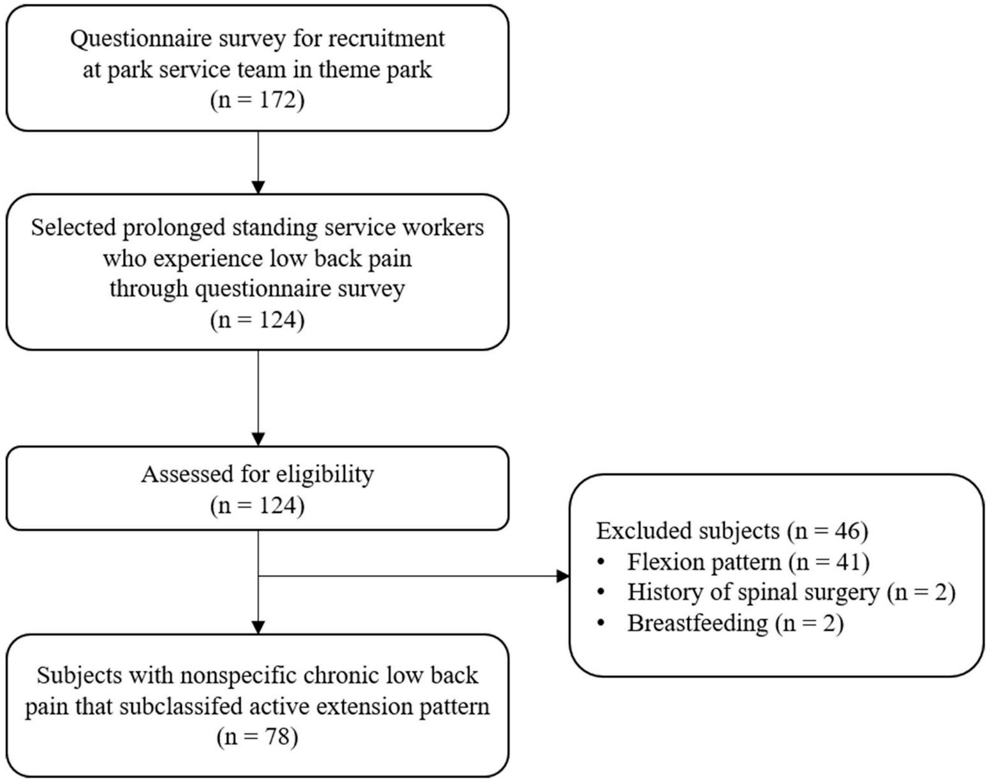

Fig. 1. Flow diagram showing the selection process of study participants.

Table 2
Subject characteristics.

Characteristics	Total (n = 78)	Males (n = 37)	Females (n = 41)
Age (y)	36.5 ± 7.7	39.4 ± 8.3	33.9 ± 6.2
Body height (cm)	169.2 ± 7.1	174.3 ± 5.7	164.6 ± 4.7
Body mass (kg)	64.6 ± 13.7	75.0 ± 11.6	55.2 ± 6.9
BMI (kg/m^2)	22.4 ± 3.7	24.6 ± 3.4	20.4 ± 2.5
VAS	4.7 ± 2.1	4.6 ± 2.1	4.7 ± 2.1
ODI	7.2 ± 4.6	6.7 ± 4.4	7.6 ± 4.7

BMI, body mass index; VAS, visual analog scale; ODI, Oswestry Disability Index.

in 90° of flexion. Pressure on the sensor was increased by 10 mmHg while the abdominal drawing-in maneuver was performed by the subjects. HE ROM was defined as LS and measured when pressure decreased below 50 mmHg during HE (Fig. 3). The average values from both sides were calculated for LS.

2.3.5. Strength measurement

For muscle strength measurement, an ankle or thigh strap was used to apply the muscle strength sensor. The belt length was adjusted to measure isometric strength in the start position. Subjects were asked to maintain maximal strength for 5 s and the middle 3 s were used to calculate the average value. All data were divided by the subject's weight for normalization. The average values from both sides were calculated. Table 3 shows the subject position and procedure for each muscle strength test.

2.3.6. Statistical analyses

The Kolmogorov-Smirnov Z test was used to assess the normality of distribution of the data. Pearson correlation matrices were constructed to examine the relationships among VAS, ODI and the 14 independent variables. Multiple regression models with a stepwise selection procedure included the 14 independent variables, with VAS and ODI used as dependent variables. The determination coefficient (R^2) denoted the explanatory power of the variables. Statistical analyses were conducted using SPSS software (ver. 18.0; SPSS Inc., Chicago, IL, USA) and statistical significance was set at $p = 0.05$. We also performed post hoc power analyses using G∗ Power software (ve. 3.1.2; Franz Faul, University of Kiel, Kiel, Germany) to confirm that the number of subjects was sufficient to achieve a large power according to Cohen (1988).

Table 1
Inclusion and exclusion criteria for the NSCLBP participants subclassified as AEP.

Inclusion criteria
LBP for a minimum of 12 weeks
Pain in the lumbar regions
Clear mechanical basis of disorder: specific postures and movements that aggravate and ease the symptoms, and symptom relief via movements opposite to those of provocation testing, as determined by subjective and objective clinical examination
Clinical diagnosis of motor control impairment in AEP
Key clinical features of AEP
Symptoms provoked by movements and postures involving extension of the lower lumbar spine
Symptoms eased by movements involving spinal flexion
Difficulty in adopting and/or maintaining a neutral spine posture, with a tendency toward hyperextension of the lower lumbar spine
Exclusion criteria
Not fulfilling inclusion criteria
Red flags (specific causes of LBP, such as disc prolapse with radicular pain, inflammatory disease, or other serious pathology)
Pregnancy/breastfeeding
History of spinal surgery
Vestibular/visual/neurological dysfunction affecting balance
Unable to sit and/or stand from a stool unaided

All inclusion criteria had to be satisfied based on the O'Sullivan classification.
AEP, active extension pattern; NSCLBP, nonspecific chronic low back pain; LBP, low back pain; AEP, active extension pattern.

Fig. 2. Range of motion (ROM) was measured using a motion sensor for hip flexion (HF), hip extension (HE), and knee flexion (KF). (A) HF: a strap with a motion sensor placed on the thigh between the greater trochanter and knee joint. (B) HE: a strap with a motion sensor placed on the thigh between the greater trochanter and knee joint. KF: a strap with a motion sensor placed on the ankle above the lateral malleolus.

3. Results

All variables satisfied a normal distribution ($p > 0.05$). Table 4 shows the correlation coefficients between the independent and dependent variables.

Stepwise multiple regression analyses were performed to identify variables that contributed significantly to VAS and ODI scores in PSSWs with NSCLBP subclassified as AEP. In the stepwise regression analyses, model 5 accounted for 40.1% of the variance in VAS scores (Table 5); model 2 accounted for 11.9% of the variance in ODI scores (Table 5).

Unstandardized and standardized coefficients are shown in Table 5; based on the independent variables, the regression equations were determined using the slope and constant values. β values, as standardized coefficients of the effects of variables in model 5 on VAS scores, were as follows: HArS ($\beta = -0.321$), HE ROM ($\beta = -0.196$), LS ($\beta = -0.166$), KOSS ($\beta = 0.199$), and PATA ($\beta = 0.241$); for ODI scores in model 2 the β values were as follows: HERrS, $\beta = -0.300$; and age, $\beta = 0.243$).

Post hoc power analyses were performed with the statistical significance level set at $p = 0.05$, for a total sample size of 78, 15 predictors, and an effect size of f (Van Tulder and Koes, 2006) = 0.667 (calculated based on $R^2 = 0.401$ in model 5). The power value determined was 1.00; thus, the post hoc analysis confirmed that the power was sufficient for multiple regression analysis.

4. Discussion

Characteristics were compared among subgroups of patients with NSCLBP, classified based on the direction in which movement of the lumbar spine was painful (Dankaerts et al., 2006a, 2006b; Kim et al., 2013). In the present study, we showed that HArS, LS, PATA, KOSS, and HE ROM were significant predictors of VAS scores, and HERrS and age were significant predictors of ODI scores in PSSWs with NSCLBP subclassified as AEP. These results could inform guidelines for interventions or exercises to decrease pain intensity and dysfunction in PSSWs with NSCLBP subclassified as AEP.

4.1. Predictors of VAS scores in NSCLBP subclassified as AEP

In model 1 for predicting VAS scores ($p < 0.001$, $R^2 = 20.9\%$), the β value for HArS was -8.852 (negative slope in the regression equation). The HAr functions as a pelvic stabilizer (Gottschalk et al., 1989). Previous studies showed that subjects with LBP (26–27.87 kPa) present with weaker HArS compared with subjects without LBP (32–33.51kpa) (Nourbakhsh and Arab, 2002; Arab and Nourbakhsh, 2010). In addition, 76% of individuals defined as pain or non-pain developers were correctly classified based on bilateral co-activation of the gluteus medius during a 2-h standing, with heightened co-activation confirmed as the predisposing factor for pain development (Nelson-Wong et al., 2008). PSSWs in theme parks stand for more than 8 h because they are required to guide moving lines, take food orders, and sell products. Decreased HArS may lead to increased load on the quadratus lumborum to achieve pelvic stabilization in PSSWs. In our analysis, the negative slope indicated that VAS scores decreased as HArS increased. Thus, HArS should be considered in the management of LBP in PSSWs with AEP.

In model 2 for predicting VAS scores ($p < 0.001$, $R^2 = 27.5\%$), the β value for LS was -0.0233 (negative slope in the regression equation). The LS exercise required that the subject extends the hip and knee of one leg with both feet off the supporting surface, to prevent motion of the spine during movements of the lower extremities and to improve the performance of the lower abdominal muscles in cases of lumbar extension syndrome (Sahrmann, 2002). Therefore, additional control of lumbar motion via a pressure biofeedback unit during the LS exercise detailed previously was suggested for correction of uncontrolled lumbar extension (Comerford and Mottram, 2012). Previous studies measured core muscle strength (Stickler et al., 2015; Vezina and Hubley-Kozey, 2000), endurance (McGill et al., 1999), and trunk stability (Comerford and Mottram, 2012; Cook et al., 2014) to determine LS. A negative slope in the regression equation indicated that VAS scores decreased with increasing LS in PSSWs.

In model 3 for predicting VAS scores ($p < 0.001$, $R^2 = 33.1\%$), the β value for PATA was 0.100 (positive slope in the regression equation). Pelvic position can directly influence lumbar spine alignment (Endo et al., 2012), misalignment of which is a risk factor for LBP (Dankaerts et al., 2006b; Chaléat-Valayer et al., 2011). The lumbar lordosis angle similarly predicted 22% of the variance in VAS scores (unstandardized coefficient: 0.67) in subjects who experienced LBP while standing (classified as pain developers) (Sorensen et al., 2015). An increase of 2° in lumbar lordosis has also been shown to result in large stress peaks in the posterior annulus of the intervertebral disc and facet joints, rather than to an even distribution of stress while in a neutral position (Shirazi-Adl, 1991; Adams, 2004). PATA is constant in PSSWs, which

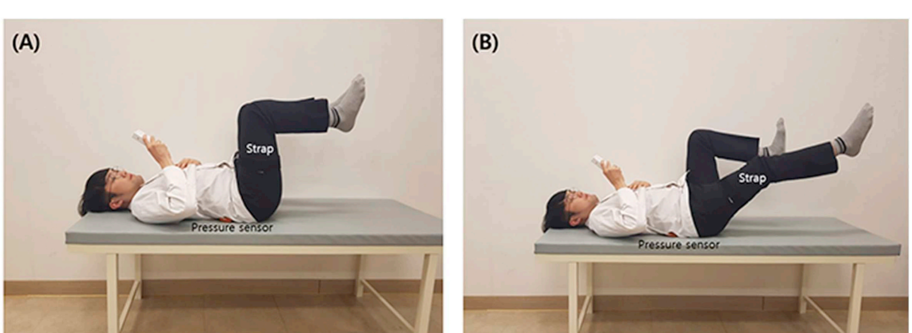

Fig. 3. Lumbopelvic stability (LS) measurement using pressure and motion sensors. (A) Sensor position: a strap with a motion sensor placed on the thigh between the greater trochanter and knee joint. Measurement of HE ROM when the pressure on the sensor placed below the lordotic curvature was increased by 10 mmHg while performing the abdominal drawing-in maneuver.

Table 3
Description of the strength measurements.

Strength measurements	Strap placement	Position	Procedure	Figure
Hip extensor	Distal thigh	Prone	The examiner controlled the subject's lumbar rotation during hip extension (HE). Subjects performed HE against a strap to maximal voluntary isometric contraction (MVIC) twice.	
Hip abductor	Distal thigh	Side-lying	Subjects were positioned on their side for contralateral measurement. The contralateral side was flexed for stability. The hip and knee joint of the dominant leg was extended to 0°. Subjects performed hip abduction against a strap to MVIC twice.	
Hip external rotator	Ankle	Side-lying	Subjects were positioned on their side for ipsilateral measurement. The position of the leg tested was HE 0° and knee flexion was 90°. The opposite side hip and knee were flexed, and the foot was positioned in front of the knee on the tested side. Subjects performed hip external rotation against a strap to MVIC twice.	

Table 4
Descriptive statistics for variables and results of Pearson correlation (n = 78).

Variable	Mean ± SD	VAS		ODI	
		Pearson correlation			
		r	*p*	r	*p*
VAS score	4.58 ± 2.20	1.000	–	–	–
ODI	7.15 ± 4.55	–	–	1.000	–
LC (°)	39.36 ± 24.87	−0.252	0.013*	−0.115	0.158
PATA (°)	14.21 ± 5.38	0.360	0.001*	0.176	0.061
KOSS	98.54 ± 11.10	0.290	0.005*	0.050	0.330
Hip extension ROM (°)	22.42 ± 4.87	−0.346	0.001*	−0.127	0.133
Hip extensor strength (kg/weight)	0.24 ± 0.10	−0.116	0.155	−0.062	0.294
Hip abductor strength (kg/weight)	0.29 ± 0.11	−0.457	0.000**	−0.250	0.014*
Hip external rotator strength (kg/weight)	0.14 ± 0.05	−0.186	0.051	−0.250	0.014*

SD, Standard deviation; VAS, visual analog scale; ODI, Oswestry Disability Index; LC, lumbopelvic control; PATA, pelvic anterior tilting angle; KOSS, Korean Occupational Stress Scale; ROM, range of motion; $^{*}p < 0.05$, $^{**}p < 0.001$.

could lead to insufficient rest time for normal tissue adaptation and recovery (Sahrmann, 2002; McGill, 1997), subsequently accelerating the rate of mechanical damage to the posterior annulus of the intervertebral disc and facet joints. A positive slope in the regression equation indicated that VAS scores increased when PATA was higher.

In model 4 for predicting VAS scores ($p < 0.001$, $R^2 = 36.6\%$), the β value for KOSS was 0.039 (positive slope in the regression equation). Greater focus on the role of the nervous system in pain modulation has coincided with research investigating the impact of psychological and social factors on pain modulation, and specifically, their capacity to influence central nervous system-mediated pain via the forebrain (Linton, 2000; Zusman, 2002). PSSWs in theme parks perform various service tasks, such as loading rides or selling tickets to customers. Because the service workers in theme parks must smile when interacting with more than 30,000 customers per day, this can be classified as emotional work, which could increase job stress; such stress can in turn modulate pain levels and cause LBP. A positive slope in the regression equation indicated that VAS scores increased with higher levels of job stress.

In model 5 for predicting VAS scores ($p < 0.001$, $R^2 = 40.1\%$), the β value for HE ROM was −0.088 (negative slope in the regression equation). Normal HE mobility is important for a normal mechanical load distribution when standing (Roach et al., 2015). Previous studies indicated that subjects with NSCLBP had significantly shortened hip flexors, with an average difference of 10° in HE ROM between subjects with NSCLBP and controls (Paatelma et al., 2009; Evans et al., 2005; Mellin, 1988). Furthermore, subjects who stand for long periods tend to show an excessive PATA during gait to compensate for the lack of HE ROM (Thambyah et al., 2003). Decreased HE ROM may be compensated for through mechanisms such as excessive anterior pelvic tilt, during prolonged standing while working. In the regression equation, a negative slope indicated that VAS scores increased when HE ROM was reduced.

4.2. ODI predictors of NSCLBP subclassified as AEP

In model 1 for predicting ODI scores ($p = 0.027$, $R^2 = 6.3\%$), the β value for HERrS was −24.183 (negative slope in the regression equation). HERrS plays an important role in daily activities (Augustsson, 2016). HERrS deficits are associated with the femoral position of adduction and internal rotation at the knee. Increased PATA due to poor posture in the AEP subgroup could decrease gluteus muscle activity and affect femoral internal rotation and adduction (Hodges and Richardson, 1997; Oh et al., 2007; Leung et al., 2015). HERrS weakness may lead to poor stabilization of the lumbopelvic region and excessive load on joints during prolonged standing. In this study, a negative slope in the regression equation indicated that ODI scored increased as HERrS decreased.

In model 2 for predicting ODI ($p = 0.009$, $R^2 = 11.9\%$), the β value for age was 0.143 (positive slope in the regression equation). The musculoskeletal problems that develop with age tend to decrease flexibility and ROM, eventually resulting in LBP. In this study, ODI scores increased with age, consistent with a previous study (Dionne et al., 2006).

The current study had several limitations. First, it used a cross-sectional in design; therefore, longitudinal studies are needed to demonstrate causal relationships. Second, electromyography and biomechanical analysis were not performed for assessing lumbar extension load in the PSSWs. Thus, future electromyographical and biomechanical studies are required to confirm the lumbar extension load in this population.

Table 5
Results of stepwise multiple regression analyses: coefficients of independent variables in models.

Dependent variable	Model	Independent variable	R (Van Tulder and Koes, 2006)	Adjusted R^2	*p*	Unstandardized coefficients		Standardized coefficients	t	*p*
						B	Standard error	β		
VAS	1	HArS	0.209	0.199	0.000	−8.852	1.974	−0.457	−4.484	0.000
	2	HArS	0.275	0.256	0.000	−8.899	1.903	−0.460	−4.677	0.000
		LC				−0.023	0.009	−0.256	−2.606	0.011
	3	HArS	0.331	0.304	0.000	−7.718	1.899	−0.399	−4.063	0.000
		LC				−0.021	0.008	−0.240	−2.513	0.014
		PATA				0.100	0.040	0.246	2.499	0.015
	4	HArS	0.366	0.331	0.000	−7.156	1.883	−0.370	−3.801	0.000
		LC				−0.016	0.009	−0.182	−1.867	0.066
		PATA				0.106	0.039	0.261	2.694	0.009
		KOSS				0.039	0.019	0.197	2.003	0.049
	5	HArS	0.401	0.359	0.000	−6.204	1.901	−0.321	−3.264	0.002
		LC				−0.015	0.008	−0.166	−1.732	0.088
		PATA				0.098	0.039	0.241	2.538	0.013
		KOSS				0.039	0.019	0.199	2.066	0.042
		HE ROM				−0.088	0.043	−0.196	−2.045	0.044
ODI	1	HERrS	0.063	0.050	0.027	−24.183	10.729	−0.250	−2.254	0.027

VAS, visual analog scale; ODI, Oswestry Disability Index; HArS, hip abductor strength; LC, lumbopelvic control; PATA, pelvic anterior tilting angle; Korean Occupational Stress Scale; HE ROM, hip extension range of motion; HERrS, hip external rotator strength.

5. Conclusions

The assessment of HArS and HERrS, LS, PATA, occupational stress, HE ROM and age would be able to predict the amount of LBP intensity and dysfunction through a multiple regression equation in PSSWs. The present results suggest that HArS and HERrS, LS, PATA, occupational stress, HE ROM and age should be considered for evaluating, predicting and preventing NSCLBP subclassified as AEP in service workers, and when designing interventions.

Ethics approval

The study protocol was approved by the Yonsei University Wonju Institutional Review Board (1041849-201709-BM-105-02).

Conflicts of interest

The authors declare that they have no potential conflicts of interest with respect to the research, authorship, and publication of this article.

Registration of clinical trials

Clinical trials number: KCT0002740.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.msksp.2019.01.014.

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