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Predictors of dysfunction and health-related quality of life in the flexion pattern subgroup of patients with chronic lower back pain

The STROBE study

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Abstract

Findings about predictors of chronic lower-back pain (CLBP) were inconsistent and inconclusive in previous studies because patients with CLBP are heterogeneous. Subgrouping patients with CLBP, according to a CLBP classification system, might thus clarify the research findings. CLBP in the direction of lumbar flexion movement, that is, the flexion pattern, is common in clinical situations. Therefore, the purpose of this study was to determine the predictors of dysfunction (pain, disability) and health-related quality of life in the flexion pattern subgroup of patients with CLBP.

A cross-sectional study of prospectively collected data. One hundred eight subjects in the flexion pattern subgroup of CLBP. Thirteen variables were measured: the visual analog scale (VAS), the Oswestry Disability Index (ODI), the Short Form-36 (SF-36), the Beck Depression Inventory (BDI), hip internal rotation range of motion, hip flexion range of motion, knee extension range of motion, knee extension with dorsiflexion range of motion, ratio forward flexion, knee extension strength, hip extension strength, hip flexion strength, and lumbopelvic stability.

The models for predictors of lower-back pain in the CLBP flexion pattern subgroup included knee extension and the BDI as predictor variables that accounted for 8.1% of the variance in the VAS ($P < .05$); predictors for disability included the BDI, age, and hip flexion strength, which accounted for 21.2% of the variance in the ODI ($P < .05$); predictors for health-related quality of life included the BDI, sex, knee extension with dorsiflexion range of motion, and age, which accounted for 38.8% of the variance in the SF-36 ($P < .05$) in multiple regression models with a stepwise selection procedure.

The current results suggest that knee extension, the BDI, age, hip flexion strength, knee extension with dorsiflexion, and sex should be considered when determining appropriate prediction, prevention, and intervention in the flexion pattern subgroup of patients with CLBP.

Abbreviations: BDI = beck depression inventory, CLBP = chronic lower-back pain, HES = extensor strength, HF = hip flexion, HFS = hip flexor strength, KE = knee extension, KED = knee extension during ankle dorsiflexion, KES = knee extensor strength, LBP = lower-back pain, LS = lumbopelvic stability, MVIC = maximal voluntary isometric contraction, PBU = pressure biofeedback unit, QOL = health-related quality of life, ROM = range of motion, SF-36 = short Form 36, TFR = trunk flexion ratio, VAS = visual analog scale.

Keywords: chronic, classification, lower-back pain, lumbar flexion pattern, predictor

1. Introduction

Lower-back pain (LBP) is common, with a lifetime prevalence in the general population of 80%.[1–5] Chronic lower-back pain (CLBP) is defined as persistent LBP for at least 3 months, which accounts for 23% of LBP.[6] A mechanical response is one that occurs when the mechanical presentation changes with movement in response to a particular loading, and CLBP is mostly mechanical.[7] Mechanical CLBP may be caused by several influencing factors affecting LBP; therefore, it is important to identify the influencing factors that can predict mechanical CLBP for predicting, preventing, and intervening in CLBP.

CLBP is a bio-psychosocial pathology,[5,7] and negative thinking, pathological fear, and abnormal anxiety regarding pain, avoidant behavior, and depression are associated with levels of pain, disability, and muscle guarding.[8–10] Individual factors are also considered influencing factors for CLBP. As individuals get older, they are more exposed to musculoskeletal diseases,[11] severe LBP.[11,12] Male has more common CLBP because they are less flexible than female.[13–15] Decrease of muscle strength, activity range of motion, and dysfunction is common in the CLBP group. Previous studies reported that individuals with CLBP have decrease strengths of knee extensor,[16] hip flexor,[17] abdominal muscles,[18–20] and activity of hip extensors,[21] lumbopelvic stability,[22] and range of motion (ROM) of hip flexion, internal rotation, and knee extension.[23–29] In contrast, other studies have shown no significant difference in abdominal muscle strength and

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ROM of knee extension between individuals with and without CLBP.[17,30–32]

Despite the many significant studies about CLBP, the relationship between CLBP and predictors (influencing factors) remains inconsistent and inconclusive.[15,33] This is because patients with LBP are a heterogeneous group who can be divided into several subgroups in which symptoms occur due to different mechanical factors, and to find the correct predictor, it should be divided into homogenous groups.[3,5,7,15,34] For treatment and research of CLBP, classification systems were established according to the direction of painful movement of the lumbar spine and has proven reliability for classifying LBP subgroups.[5,7,34–39] According to Wand et al, 58% of patients with CLBP complain of pain in the flexion direction of movement and patients with CLBP in the direction of lumbar flexion movement, that is, the flexion pattern, are common in a clinical context.[5,7,40,41] This may be because sitting has become the most common posture in the workplace, with the spread of computer-based work.[7,36]

A treatment-based classification system for CLBP is functionally effective and cost-effective.[42] However, despite the importance of a classification system for managing CLBP, few studies have investigated the predictors of homogeneous (classifying) CLBP according to painful movement of the lumbar spine. Among the homogeneous subgroups, it is necessary to study the flexion pattern subgroup of patients with CLBP because the flexion pattern is now common.[7,40] If predictors of dysfunction and health-related quality of life (QOL) in the flexion pattern subgroup could be identified, appropriate prediction, prevention, and intervention would follow for the flexion pattern subgroup of patients with CLBP. Therefore, the purpose of this study was to determine the predictors of dysfunction (pain, disability) and QOL in the flexion pattern subgroup of patients with CLBP.

2. Methods

2.1. Subjects

Screening based on classification of the movement impairment syndrome by Sahrmann was used to confirm the subgroup with a lumbar flexion pattern among those with mechanical CLBP. A 4-year career physiotherapist performs the following tests on the participant, and if the participant complains of pain, it is a positive sign: forward bending; alignment in quadruped, rock backward in quadruped; alignment in sitting position, knee extension in sitting; hip and knee flexion in supine. The exclusion criteria were spinal canal stenosis, spondylolisthesis, spondylitis, large herniated disc sciatica, radiating pain below the knee, previous back surgery, history of known spinal fractures, malignancy, known muscle, nerve, skin, or joint diseases, and pregnancy.[43] Of the 150 participants, 108 subjects participated in this experiment. Their characteristics are shown in Table 1. This study was approved by Yonsei University Wonju Institutional Review Board (1041849-201701-BM-008-02).

Table 1

Subject characteristics.

Characteristic	Total (N=108)	Male (N=78)	Female (N=30)
Age, y	32.44±6.51	33.56±5.94	29.53±7.11
Body height, cm	172.26±7.29	175.55±5.17	163.71±4.48
Body mass, kg	71.52±12.26	75.82±8.85	60.36±12.96
Pain duration, mo	29.06±32.81	31.76±36.44	22.03±19.41
VAS, mm	58.48±17.52	58.51±18.09	58.40±16.22
ODI, %	14.87±7.15	14.04±6.46	17.02±8.44
SF-36, %	68.89±7.20	70.33±7.15	65.15±5.94

ODI=Oswestry Disability Index, SF-36=Short Form 36, VAS=Visual Analog Scale.

2.2. Outcome measure

2.2.1. Questionnaire. The Visual Analog Scale (VAS) and the Oswestry Disability Index used dysfunctions for dependent variables in this study.[44–46] The Short Form 36 (SF-36) is used as a measure of QOL,[47] and the Beck Depression Inventory (BDI), created by Aaron T. Beck, is used psychometric tests for measuring depression severity.[48]

2.2.2. Measurement of range of motion. The ROM of the hip flexion, knee extension, knee extension with dorsiflexion, hip internal rotation, trunk flexion ratio, and hip extension during lumbopelvic stability were measured with the aid of a Smart KEMA motion sensor (KOREATECH Co, Ltd, Seoul, Korea). The motion sensors contained a tri-axillar gyroscope, a magnetometer, and an accelerometer, as well as a signal converter and a signal transmission sensor. Motion sensor data were transmitted to a recording android tablet with Smart KEMA software, using a 25 Hz sampling frequency.

2.2.3. Hip internal rotation. During measurement of hip internal rotation (HIR) ROM, the ipsilateral knee joint was flexed 90° in a prone position. To prevent pelvic rotation during hip rotation, the pelvis was stabilized with manual pressure. Simultaneously, the ipsilateral lower leg was moved to the end range of HIR[49] (Fig. 1).

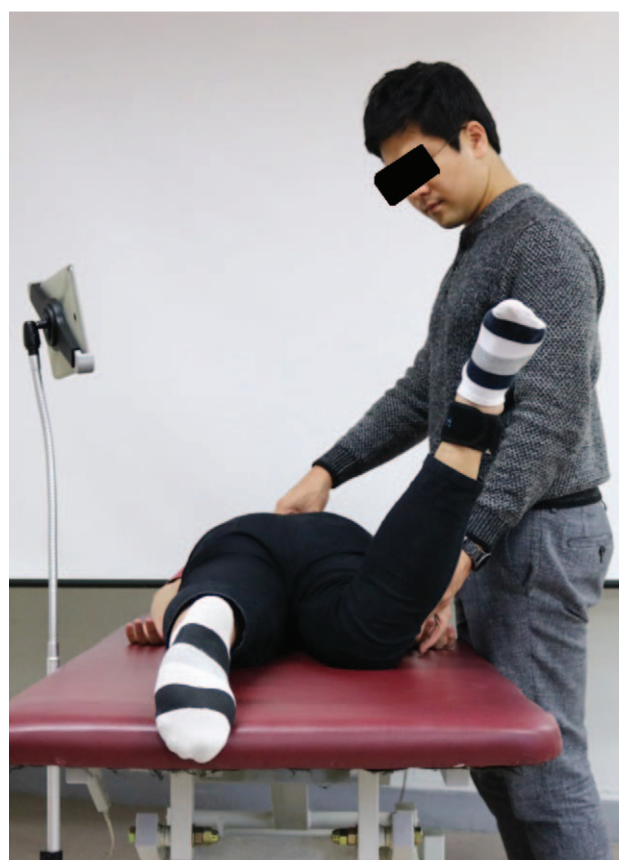

Figure 1. Measurement of hip internal rotation.

Figure 2. Measurement of hip flexion.

2.2.4. *Hip flexion.* Individuals with the lumbar flexion pattern can usually flex the lumbar spine during the measurement of hip flexion (HF) ROM in the supine position.[36] In this study, HF was measured without lumbar motion using a PBU. The subjects were guided but not assisted by the examiner during active hip flexion.[50,51] We used a PBU to maintain pressure (40 ± 2 mmHz) below the lordotic curve of the spine between S1 and L1 during HF. ROM was measured twice when the pressure was raised to >42 mm Hz during HF. The motion strap with sensors was placed on the thigh between the greater trochanter and knee joint (Fig. 2).

2.2.5. *Knee extension.* Other studies have used the straight leg raising test for analyzing hamstring ROM.[52,53] However, this test is accompanied by pelvic tilting, which is difficult to control.[17,54] Thus, in this study, the knee extension (KE) ROM was measured in the sitting position as the pelvis was stabilized.[36,55] Each subject sat in an upright sitting position and then performed active KE with the ankle in the relaxed plantar flexion. To prevent lumbar flexion and pelvic posterior tilting during KE, the pelvis was stabilized by the examiner.[36] ROM was measured twice in the end range of KE without a pelvic tilt. A motion strap with sensors was placed on the ankle above the lateral malleolus (Fig. 3).

2.2.6. *Knee extension during ankle dorsiflexion.* The knee extension during ankle dorsiflexion (KED) ROM was also measured in a sitting position with the pelvis stabilized.[36] Each subject sat in an upright sitting position and then performed active KE with the ankle in dorsiflexion. To prevent lumbar flexion and pelvic posterior tilting during KE, the pelvis was stabilized by the examiner.[36] ROM was measured twice in the end range of KE without a pelvic tilt. A motion strap with sensors was placed on the ankle above the lateral malleolus (Fig. 3).

2.2.7. *Trunk flexion ratio.* Trunk flexion was defined by the point at which the subjects' fingertips reached the midline of the tibia.[56,57] A Bobath table was set up behind the hip (greater trochanter line of the femur) to match ankle dorsiflexion. The distance between the table and the hip was set to 8 cm. Smart KEMA motion sensors were placed between the posterior superior iliac spine (sacrum) and the L1–L2 spinous process (upper lumbar). Lumbar and pelvic motion during trunk flexion was monitored and measured in real time using the electronic 2-inclinometer method.[57–59] The trunk flexion ratio (TFR) was defined by the ROM of lumbar flexion/pelvic anterior tilting. ROM was measured twice in the end range of trunk flexion until reaching the midline of the tibia (Fig. 4).

2.2.8. *Measurement of strengths and stability.* The isometric strengths of knee extension, hip extension, and hip flexion were measured using a Smart KEMA tension sensor (KOREATECH Co, Ltd). The tension sensor contained a load cell that had a measurement range of 0 to 1960 N, with an accuracy of 4.9 N. The tension sensor data were transmitted to a recording android tablet running Smart KEMA software at a 10 Hz sampling frequency. Strength was normalized by body weight (N/kg). A pressure biofeedback unit (Stabilizer, Chattanooga Group Inc, Hixson, TN) and the Smart KEMA motion sensor were used to measure lumbar stability.

2.2.9. *Knee extensor strength.* To measure knee extensor strength (KES), the length of the restraining belt was adjusted so that the subjects could reach KE of 45°.[60,61] The subjects performed KE against a strap anchored by a glass suction cup or stable material to maximal voluntary isometric contraction (MVIC) twice for 5 seconds each time. A strap (ankle strap) was fixed to the ankle above the lateral malleolus. The subjects were shown how to stabilize themselves by holding onto the side of the table with their hands while sitting upright. Strength was analyzed by averaging the middle 3 seconds of each 5-second measurement. Strength was normalized by body weight (N/kg) (Fig. 5).

2.2.10. *Hip extensor strength.* To measure hip extensor strength (HES), subjects flexed the knee to 90° in the prone position while the leg was slightly off to the side of the table.[62] The strap (thigh strap) was fixed to the femur 2 cm above the popliteal fossa, and a glass suction cup or stabilizer was fixed on

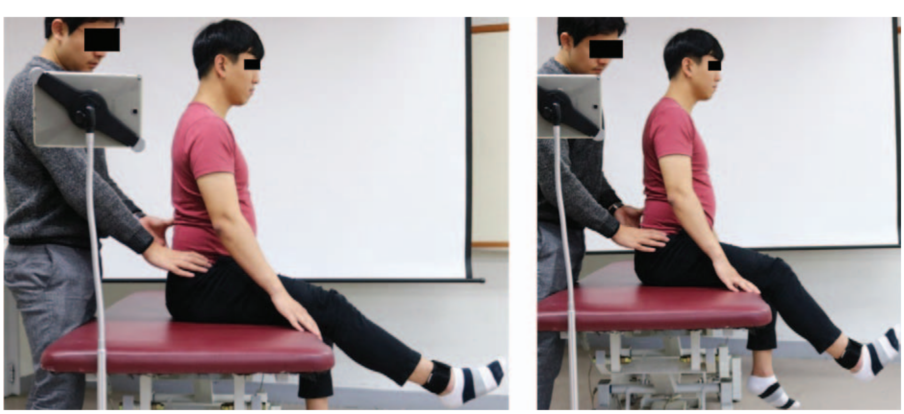

Figure 3. Measurement of knee extension during ankle dorsiflexion.

Figure 4. Measurement of trunk flexion.

Figure 5. Measurement of knee extension strength.

the floor to fix the restraining belt. The examiner adjusted the length of the restraining belt to 5° of hip extension. The examiner fixed the lumbopelvic rotation of the subjects during hip extension. The subjects performed hip extension against a strap anchored by a glass suction cup or stabilizer for MVIC twice for 5 seconds each time. The subjects sat upright on the edge of a therapeutic table to measure HES at 90° hip and knee flexion (Fig. 6).

2.2.11. Hip flexor strength. To measure hip flexor strength (HFS), each subject sat in an upright sitting position at the edge of a Bobath table. A thigh strap was fixed to the femur 2 cm above the popliteal fossa. The examiner adjusted the length of the restraining belt to 5° of hip flexion. The subjects performed hip flexion against a strap anchored by a glass suction cup or stabilizer for MVIC twice for 5 seconds each time.[63,64] To prevent lumbar flexion and trunk sway during hip flexion, the subjects stabilized their trunk by holding the table with their hands (Fig. 7).

2.2.12. Lumbopelvic stability. To measure lumbopelvic stability (LS), subjects flexed the hip and knee 90° in a supine position. Ipsilateral hip and knee extensions were performed to maintain abdominal pressure without the leg or foot touching a supporting surface.[36] Abdominal pressure was checked with a PBU. The PBU was set to 40 mm Hg and was placed below the lordotic curve of the spine between S1 and L1 with the hip and knee in 90° of flexion. Then, the pressure of the PBU was increased by 10 mm Hg while the abdominal drawing-in maneuver was performed by the subjects.[65] ROM of hip extension was defined as LS and was measured once when the pressure decreased below 50 mm Hg during hip extension (Fig. 8).

Figure 6. Measurement of hip extensor strength.

Figure 7. Measurement of hip flexor strength.

2.3. Procedure

The following variables were measured in all subjects in the following order: psychological factors, ROM, and strength. First, subjects were instructed to fill out the questionnaires (VAS, Oswestry Disability Index, BDI, and SF-36). Then, ROM (hip internal rotation, hip flexion, knee extension, and knee extension with dorsiflexion), strength (hip flexion, hip extension, and knee extension), and lumbopelvic stability was measured in random order. The random order was determined by drawing lots. The subjects were instructed to perform measurements of strength and ROM, and became familiar with the measurements during 10 minutes.

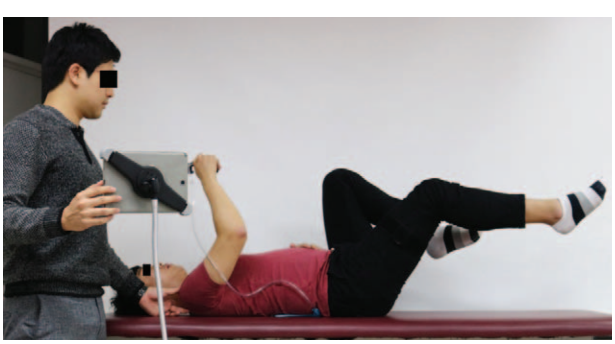

Figure 8. Measurement of lumbopelvic stability.

2.4. Statistical analysis

The Kolmogorov–Smirnov Z test was used to confirm the normality of the distribution. If a normal distribution of the variables was confirmed, the correlations between the variables were checked using Pearson correlation analysis. To investigate which variables contributed most significantly to dysfunction and QOL, multiple stepwise selection regression models were performed for hip internal rotation, hip flexion, knee extension, knee extension with dorsiflexion, trunk flexion ratio, knee extension strength, hip extension, hip flexion strength, lumbopelvic stability, and BDI as independent variables, whereas VAS, Oswestry Disability Index, and SF-36 were the dependent variables. The determination coefficient (R^2) indicates the power (predictive value) that was explained by the multiple regression variables. Intra-rater reliability for each measurement was calculated in a pilot study (n = 16) using the ICC (3, 1) model. All statistical analyses were performed using SPSS software (ver. 24.0; SPSS, Inc, Chicago, IL). The level of statistical significance was set at $P < .05$. G * power (ver. 3.1.2; Franz Faul, University of Kiel, Kiel, Germany) was used for the post hoc power analysis.

3. Results

All variables were normally distributed ($P > .05$). Table 2 shows the correlation coefficients between the independent variables. In the stepwise regression analyses, model 2 included knee extension and BDI as predictors and accounted for 8.1% of the variance in the VAS (Table 3; $P < .05$) using the following model: $Y = 70.797 + (\text{knee extension} \times -0.353) + (\text{BDI} \times 0.576)$. Model 3 included the BDI, age, and hip flexion strength as predictors and accounted for 21.2% of the variance in the Oswestry Disability Index (Table 3; $P < .05$) using the following model: $Y = 8.934 + (\text{BDI} \times 0.438) + (\text{age} \times 0.237) + (\text{hip flexion strength} \times -0.023)$. Model 4 included the BDI, sex, knee extension with dorsiflexion, and age as predictors and accounted for 38.8% of the variance in the SF-36 (Table 3; $P < .05$) using the following model: $Y = 75.585 + (\text{BDI} \times -0.568) + (\text{sex} \times -5.338) + (\text{knee extension with dorsiflexion} \times 0.136) + (\text{age} \times -0.194)$. The post hoc power analysis was performed by setting the significance level $P = .05$, total sample size = 108, number of predictors = 12, and effect size $F^2 = 0.57$ (by calculating from $R^2 = 0.388$ in SF-36 model 4). The power value was computed to be 1.00. Thus, the post hoc power analysis confirmed that the power was sufficient for multiple regressions (Tables 2 and 3).

4. Discussion

In previous studies characteristics were usually compared among each pattern subgroup of patients with CLBP based on the direction of painful movement in the lumbar spine.[3,4,33,66–69] Although previous studies clarified the differences in characteristics between each pattern subgroup with CLBP, it is unclear which influencing factors predict the severity of dysfunction within each pattern subgroup. Thus, in this study, we investigated which predictors were related to the severity of dysfunction in the flexion pattern subgroup of patients with CLBP and demonstrated that 2 variables (knee extension and BDI) in the VAS, 3 variables (BDI, age, and hip flexion strength) in the Oswestry Disability Index, and 4 variables (BDI, sex, knee extension with dorsiflexion, and age) in the SF-36 were significant predictors.

Table 2

Descriptive statistics for variables and results of Pearson correlation.

		VAS		ODI		SF-36	
		Pearson correlation		Pearson correlation		Pearson correlation	
Variables	Mean ± SD	R	P	r	P	r	P
Sex (0: M, 1: F)	0.28 ± 0.45	−0.003	.489	0.188	.026*	−0.324	.000*
Age, y	32.44 ± 6.51	0.056	.284	0.178	.032*	−0.080	.206
HIR (°)	28.17 ± 9.87	0.013	.448	0.128	.093	−0.176	.034*
HF (°)	61.29 ± 20.51	−0.050	.303	0.03	.381	−0.051	.301
KE (°)	47.65 ± 11.32	−0.212	.014*	−0.004	.483	0.000	.500
KED (°)	40.46 ± 10.72	−0.210	.015*	−0.044	.325	0.104	.143
TFR	2.32 ± 0.72	0.104	.142	0.018	.428	0.142	.071
KES (%N/kg)	408.50 ± 172.01	0.034	.365	−0.167	.042*	0.132	.087
HES (%N/kg)	270.02 ± 111.31	−0.016	.434	−0.123	.102	0.093	.17
HFS (%N/kg)	229.53 ± 65.53	−0.031	.376	−0.224	.010*	0.182	.029*
LS (°)	46.30 ± 24.41	0.040	.342	−0.026	.395	0.144	.069
BDI	7.81 ± 5.78	0.171	.038*	0.359	.000*	−0.536	.000*

BDI = beck depression index, HES = hip extension strength, HF = hip flexion, HFS = hip flexion strength, HIR = hip internal rotation, KE = knee extension, KED = knee extension with ankle dorsiflexion, KES = knee extension strength, LS = lumbar stability, ODI = Oswestry Disability Index, SD = standard deviation, SF-36 = Short Form 36, TFR = trunk flexion ratio, VAS = Visual Analog Scale.
* = $P < .05$.

4.1. VAS predictors of LBP

Knee extension was a significant factor with the VAS for LBP, accounting for 4.5% of the variance ($P < .05$) in VAS model 1. Restricted knee extension has been linked to reduced lumbar lordosis[70–72] and is associated with an increased risk of developing LBP.[73,74] And Radwan et al reported that the more restricted knee extension, the higher the severity of LBP.[75] Individuals with a lumbar flexion pattern have limited knee extension because of tightness of the hamstring.[36] If the hamstring is tight during knee extension, the origin of the hamstring and tuberosity of the ischium are posteriorly tilted, which decreases lumbar lordosis and increases lumbar flexion.[72] Repeated movements during knee extension with lumbar flexion in daily living, such as driving, forward bending to wash the face, or work, may increase the incidence of pain in patients with the lumbar flexion pattern. In previous studies, knee extension was 77.2° to 84.4° in individuals without LBP and 66.5° in patients with LBP.[76] The present study found that the knee extension angle was 47.65 ± 11.32° in the flexion pattern subgroup of patients with CLBP. The result of knee extension being lower than in a previous study could be explained by the fact that we studied the flexion pattern subgroup using a classification system.

In VAS model 2, the combination of knee extension and BDI explained an additional 3.6% of the variance in the VAS of LBP ($P < .05$). Depression is relatively common in patients with CLBP.[77–80] Removing psychological risk factors, such as depression, along with treating the physical limitations of patients with CLBP effectively reduces the pain level of CLBP.[81] In this study, as the B value of unstandardized coefficients for BDI was 0.576 in model 2, a regression equation with a positive slope was set. Thus, depression is positive related factor in the severity and perception of LBP.

Table 3

Results of the stepwise multiple regression analysis for the dependent variables.

Dependent variable	Model	Independent variable	R^2	Adjusted R^2	F	P	Durbin–Watson
VAS	1	KE	0.045	0.036	4.996	.028	
	2	KE	0.081	0.063	4.094	.046	1.856
		BDI					
ODI	1	BDI	0.129	0.121	15.714	.000	
	2	BDI	0.170	0.154	5.166	.025	
		Age					
	3	BDI	0.212	0.190	5.587	.020	2.157
		Age					
		HFS					
SF-36	1	BDI	0.288	0.281	42.775	.000	
	2	BDI	0.324	0.311	5.633	.019	
		Sex					
	3	BDI	0.359	0.341	5.780	.018	
		Sex					
		KED					
	4	BDI	0.388	0.364	4.748	.032	1.945
		Sex					
		KED					
		Age					

BDI = beck depression index, HFS = hip flexion strength, KE = knee extension, KED = knee extension with ankle dorsiflexion, ODI = Oswestry Disability Index, SF-36 = Short Form 36, VAS = Visual Analog Scale.

4.2. Oswestry disability index predictors

The BDI was a significant predictor in Model 1 of the Oswestry Disability Index, accounting for 12.9% of the variance ($P < .05$). The role of psychological dimensions as prognostic factors for CLBP and disability is well known.[7] Depression has been identified as a notable mental health factor predicted to become a cause of disability.[82] Because a regression equation with a positive slope was set (B = 0.444), the disability of LBP increased with an increase in the BDI score.

The current findings show that adding the age scale increased the predictive value of the Oswestry Disability Index by 4.1% in model 2 ($P < .05$). The musculoskeletal problems that develop with age tend to decrease muscle flexibility and reduce ROM, and these problems eventually result in LBP. In this study, the correlation between age and hip internal rotation was negative ($r = -0.228$, $P < .05$). As the B value of unstandardized coefficients for the age scale was 0.222 in model 2, a regression equation with a positive slope was set. This suggests that lower-back disability increases with age, consistent with results reported by Dionne et al in 2006.

In model 3 of the Oswestry Disability Index, the combination of BDI, age, and hip flexion strength explained an additional 4.2% of the variance in the Oswestry Disability Index ($P < .05$). The agonist of hip flexion is the psoas major, and hip flexion exercise is one of the primary conventional interventions in rehabilitation to strengthen the psoas major.[83] The psoas major muscle contributes to stabilize the lumbar spine.[83–85] Magnetic resonance imaging analyses of patients with CLBP confirm that the psoas major[86,87] and hip flexion strength are significantly weaker in patients with LBP than in those without LBP.[17] In this study, we demonstrated that hip flexion strength influenced disability of the lower back. It may cause pain and disability as mechanical instability in the lumbopelvic region due to weakness in the psoas major stimulates nociceptors in the surrounding soft tissue.[88]

4.3. SF-36 predictors

BDI was a significant predictor in Model 1 of the SF-36, accounting for 28.8% of the variance ($P < .05$). BDI was entered in all regression models of the VAS, Oswestry Disability Index, and SF-36. The effect of psychological factors on dysfunction due to CLBP is significant, suggesting that it is important to consider psychological factors in the management of CLBP. Depression reduces physical activity,[89] and may lead to a decrease in QOL. In addition, as the other model results show, if depression becomes worse, QOL may decrease because of the increases in pain level and disability of the lower back.

The current findings show that the addition of the sex scale increased the predictive value of SF-36 by 3.6% in model 2 ($P < .05$). Males have greater active and passive stiffness of the lower limbs than females[13–15,90] and the lumbar flexion pattern occurs more frequently in males, as subjects with lumbar flexion syndrome appear to be less flexible in the hip joint.[36] However, in this study, the regression equation for sex had a negative slope (B = −5.338), so QOL decreased more in females than in males. Females with CLBP are less likely to perform activities of daily living than males with CLBP,[91] which may affect QOL. Because females with a lumbar flexion pattern may be significantly less flexible than healthy females, they may feel that their QOL is lower than that of others.

We also found that the combination of model 3, BDI, sex, and knee extension with dorsiflexion resulted in a 3.5% greater predictive value in the SF-36 ($P < .05$). The knee extension with dorsiflexion is widely reported in the literature as an indirect test for measuring sciatic nerve tension and as an aid in the diagnosis of sciatica and nerve root irritation[54,92] because dorsiflexion increases tension on the sciatic nerve.[53,93–95] The knee extension with dorsiflexion generally has a smaller angle than knee extension,[52,53] and knee extension with dorsiflexion is more restricted due to the pressure of lumbar intervertebral disc herniation, which frequently occurs in subjects with the lumbar flexion pattern.[96] A limitation in knee extension with dorsiflexion might interfere with activities of daily living, such as driving, forward bending, or washing the face, and affect QOL as a result.

In model 4 of SF-36, the combination of BDI, sex, knee extension with dorsiflexion, and age explained an additional 2.9% of the variance in SF-36 ($P < .05$). As individuals get older, they are more exposed to musculoskeletal diseases, such as osteoarthritis, disc degeneration, osteoporosis, spinal stenosis,[11] severe LBP,[11,12] and decreased activities of daily living.[91] As the B value of the unstandardized coefficients for age scale was −0.194 in model 4, a regression equation with a negative slope was set. Therefore, increasing age influences decreasing QOL as a result.

Several limitations of this study should be noted. First, this study had a cross-sectional design. Therefore, further longitudinal studies are needed to confirm any causal relationship between the psychological, ROM, and strength factors and dysfunctions with CLBP. Second, we employed a flexion pattern subgroup of patients with CLBP in this study. However, as the rotation component was not confirmed, the flexion-rotation pattern subgroup (lumbar flexion-rotation pattern) could also be included, which may have affected the results of this study, so a future study needs to confirm the rotation pattern. Third, we excluded participants who complained of pain or in whom it was difficult to measure strength and ROM. Thus, it would be difficult to apply these results to patients with severe CLBP.

5. Conclusions

This study investigated predictors of dysfunction in a flexion pattern subgroup of patients with CLBP. Various factors influenced dysfunction in this subgroup, and it is important to clarify the predictors for dysfunction of CLBP because these factors should be considered in the management of CLBP. The results of this study show that knee extension and BDI predicted LBP; the BDI, age, and hip flexion strength predicted disability; and the BDI, sex, knee extension with dorsiflexion, and age predicted of health-related quality of life. The investigation of knee extension, BDI, age, hip flexion strength, sex, and knee extension with dorsiflexion predicted the amount of dysfunction (pain, disability, and health-related quality of life) through a multiple regression equation. The results of this investigation can be a guide for appropriate prediction, prevention, and intervention of the flexion pattern subgroup of patients with CLBP. Further studies should determine if dysfunction in the flexion pattern subgroup of patients with CLBP decrease when these predictors are reduced through interventions.

Author contributions

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