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Original Article

Influence of Pain Self-Efficacy and Gender on Disability in Postoperative Cervical Myelopathy

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ABSTRACT

Background: Pain self-efficacy and gender may influence disability in patients with musculoskeletal disorders. The direct and interactive influence of pain self-efficacy and gender on postoperative disability with degenerative cervical myelopathy (DCM) is unclear.
Aim: This study aimed to determine the effects of age, pain, and pain self-efficacy on disability postoperatively in patients with DCM, and explore whether these effects differ by gender.
Method: A total of 180 participants who underwent DCM surgery were consecutively recruited. The following were evaluated: (1) demographic/descriptive data (age, gender, diagnosis, surgery date, procedure); (2) numerical rating scale pain and dysesthesia intensity; (3) Neck Disability Index; and (4) Pain Self-Efficacy Questionnaire. Hierarchical multiple regression analysis and simple slope analysis determined the effect of patients' biologic and psychosocial factors, and their interaction in terms of disability.
Results: The responses of 82 participants were analyzed. The hierarchical multiple regression final model analysis determined 57.1% participant disability variance; gender ($B = 3.388$; $p < .01$); pain ($B = 3.574$; $p < .01$); pain self-efficacy ($B = -0.229$; $p < .01$); age and gender ($B = -0.201$; $p < .05$); pain and gender ($B = -3.749$; $p < .01$); pain self-efficacy and gender ($B = -0.304$; $p < .01$) were significantly associated with disability. Simple slope test indicated that women showed weaker pain associations and stronger age and pain self-efficacy associations with disability than men.
Conclusions: Pain self-efficacy improvement should be focused on after surgery in patients with DCM, especially women.

With the global population aging, degenerative cervical myelopathy (DCM) is becoming increasingly prevalent worldwide (Badhiwala et al., 2020). Consequently, identifying the most effective strategies and postoperative rehabilitation for DCM has become a key public health priority (JLA, 2020). Surgical treatment is a standard method used to treat neurologic deterioration and prevent further disability in patients with DCM, and several studies have demonstrated that DCM surgical treatment results in significant improvements in pain and disability (Fehlings et al., 2017). However, according to clinical guidelines, patients with more severe myelopathy and a longer duration of symptoms may have persistent disability after surgery (Fehlingset al., 2017) because severe and long-standing compression of the spinal cord may result in spinal cord changes that cannot be reversed through decompression. Moreover, a systematic review found that age is a significant predictor of management and outcomes of DCM (Grodzinski et al., 2021). Specifically, older patients were likely to be diagnosed with more severe diseases and exhibit more significant radiologic features. Thus, it is important to better understand the factors influencing postoperative outcomes to develop targeted management strategies for high-risk patients.

The biopsychosocial model describes pain and disability as a multidimensional, dynamic integration between mutually influential biologic, psychological, and social factors, and has been gaining more interest over the last few decades (Meints & Edwards, 2018). Nevertheless, various psychosocial factors' effects on DCM prognosis have only been evaluated to a limited extent (Alvin et al., 2015; Doi et al., 2019; Kondo et al., 2021). The Fear Avoidance Model aims to elucidate the development of chronic pain and disability under various conditions including after spinal surgery, and pain catastrophizing, fear of movement, and avoid-

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ance behavior might lead to physical deconditioning and disability (Vlaeyen & Linton, 2000). Conversely, high levels of protective factors seem to avoid this vicious cycle (Slepian et al., 2020). Edwards et al. (2016) reported that pain self-efficacy is the belief in one's ability to manage and complete a task, despite pain, and is one of the important protective factors that are to be associated with the existence of higher levels of disability in musculoskeletal pain conditions (Edwards et al., 2016). Miki et al. (2021) found pain self-efficacy to be a negative factor in disability for non-acute nonspecific low back pain, and was observed to be independently correlated with pain intensity, fear of movement, and pain catastrophizing (Miki et al., 2021). Additionally, Wylde et al. (2012) found that pain self-efficacy is a significant preoperative predictor of disability at 1 year after total knee replacement (Wylde et al., 2012). Although pain self-efficacy may be a fundamental element in reducing persistent disability common to people with DCM, the influence of pain self-efficacy on disability in postoperative patients with DCM is unknown.

Recently, there has been a growing interest in gender differences in pain and disability, and a heightened recognition of the gender role in influencing psychosocial mechanisms in various musculoskeletal disorders (Meints & Edwards, 2018). Several studies have demonstrated gender differences' effect on maladaptive cognitions. For example, Keefe et al. (2000) found that pain catastrophizing mediates the gender and disability relationship, with higher levels of pain catastrophizing and higher disability in women with osteoarthritis of the knees (Keefe et al., 2000). Therefore, in order to fully understand disability and the pain self-efficacy relationship in DCM, it is necessary to consider the interactive effects of pain self-efficacy and gender on disability as well as the presence and intensity of pain (Meints & Edwards, 2018; Merlijn et al., 2003). It is important for clinicians and nurses to understand the role of gender on the effect of disability to allow them to tailor preoperative and postoperative assessment, education, and pain management strategies for individuals experiencing disability; however, there is a lack of knowledge of the interactive effects of pain self-efficacy and gender on disability in people with DCM.

Therefore, the purpose of this study was as follows: (1) investigate the effects of age, pain, and pain self-efficacy on disability in postoperative patients with DCM; and (2) explore whether these effects differ by gender. We hypothesized that the influence of age, pain, and pain self-efficacy on disability depended on gender.

Methods

Study Design and Ethical Considerations

This was a cross-sectional study that utilized written questionnaires that were mailed between August and September 2020. The study was approved by the Ethics Committee of a hospital (approval no., #000035), and was conducted in accordance with the Declaration of Helsinki. We mailed the questionnaires, research description, consent form for research participation, and consent withdrawal form to the recipients. Participants who agreed to participate were asked to return the consent form with the completed questionnaire. Otherwise, a withdrawal form was submitted and data were deleted even after the questionnaire was completed. Study participants were assured that study participation did not influence care.

Sample Size

The G*Power (Faul et al., 2007) was used to calculate the minimum sample size required for the study. Based on the effect size for pain/dysesthesia or pain self-efficacy and disability reported in a previous study (Ahmed et al., 2019; Takeshita et al., 2013), the expected effect size was estimated to be 0.25, which is a moderate to large effect size for Cohen's f^2 (Cohen, 1988). A power level of 0.80 and an alpha level of 0.05 were chosen. Therefore, this study required at least 65 participants to use the 7 independent variables in the hierarchical multiple regression analysis.

Participants

People aged 20 years and older with DCM diagnosis due to cervical spondylosis, ossification of the posterior longitudinal ligament, or disc herniation, and who had undergone surgery at our hospitals at least 1 year ago, were included in the study. Patients with cervical radiculopathy and no signs and symptoms of spinal cord compression were excluded, as were those with a history of cerebrovascular accident or other pathologic entities. A total of 180 participants who met the inclusion criteria were consecutively recruited between November 2017 and June 2019. As a result, seven had no known addresses, and 173 participants were sent questionnaires.

Measures

Patient-reported outcome measures evaluated for all participants were as follows: (1) Numerical Rating Scale (NRS) for pain and dysesthesia intensity; (2) Neck Disability Index (NDI) for disability (Takeshita et al., 2013); and (3) Pain Self-Efficacy Questionnaire (PSEQ) for pain self-efficacy (Adachi et al., 2014). Age, gender, diagnosis, date of surgery, and surgical procedure were collected from the medical records.

Disability

Disability was measured using the NDI Japanese version (Takeshita et al., 2013), which includes 10 items scored from 0 to 5, in which a higher total score indicates more significant disability. The NDI is now widely used to evaluate the efficacy of cervical surgery (Davies et al., 2016; Fehlings et al., 2017; Whitmoreet al., 2013). Previous studies have demonstrated the high internal consistency (Cronbach's alpha of all items = .89) of the NDI Japanese version (Takeshita et al., 2013).

Pain and Dysesthesia

An 11-point NRS was employed to assess the intensities of neck pain, upper limb pain, upper limb dysesthesia, and leg pain/dysesthesia, which persisted after surgery. Participants reported the average pain/dysesthesia intensity during the preceding month before outcome assessment measured with a 0 (no pain/dysesthesia) to 10 (worst imaginable pain/dysesthesia).

Pain Self-Efficacy

Pain self-efficacy was measured using the PSEQ Japanese version (Adachi et al., 2014), which includes 10 items scored from 0 to 6, in which a higher score indicates greater self-efficacy for functioning despite pain. Previous studies have demonstrated the high internal consistency (Cronbach's alpha of all items = .94) of the PSEQ Japanese version (Adachi et al., 2014).

Statistical Analyses

The pre-prepared free statistical program, HAD ver. 17 (Shimizu, 2013, 2016), was used to perform all statistical analyses. HAD is a software for psychostatistical analysis that runs on Microsoft Excel and performs multivariate analysis. Its calculation

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results match those of SPSS and SAS (Shimizu, 2013). Missing values were imputed using the multiple imputations with the chained equation method, and we set the number of substitutions at 100. Descriptive analyses were used to evaluate participant characteristics, and continuous data are expressed as the mean (standard deviation [SD]) values and categorical data as counts (percentages). The principal component analysis can not only reduce the dimensionality of data sets and increase interpretability but also minimize information loss (Jolliffe & Cadima, 2016). Because of a large number of NRS variables and limited sample size, the principal component analysis was performed in reducing the number of variables input into the subsequent hierarchical multiple regression models, where NRS scores were integrated. Four NRS scores were included in the principal component analysis: (1) neck pain; (2) upper limb pain; (3) upper limb dysesthesia; and (4) leg pain/dysesthesia. Hierarchical multiple regression models were developed to test the unique associations of DCM patients on their disability. The dependent variable included the disability (NDI), and the independent variables included the biologic factors (age, gender, and pain), psychosocial factors (PSEQ), and three interaction terms (age and gender, pain and gender, as well as PSEQ and gender). In step 1, unique associations of patients' biologic factors (age, gender, and pain) to their disability were tested. In step 2, patients' psychosocial factors (PSEQ) were added to test their unique associations with patients' disability. Finally, three interaction terms (age and gender, pain and gender, as well as PSEQ and gender) were added in step 3 to explore the moderating role of gender on the association between biologic factors, psychosocial factors, and disability. Additionally, simple slope analyses were used to investigate the interaction effects in more details. We applied the variance inflation factor (VIF) to diagnose multicollinearity possibility among all the explanatory variables, in which VIF <5 indicated no serious multicollinearity. To avoid multicollinearity, explanatory variables were centered in all hierarchical multiple regression analyses. In the regression model, $p < .05$ was considered statistically significant.

Results

Participant Characteristics and Data Completion

A set of questionnaires was mailed to 173 participants, and responses were obtained from 106 participants (61.2%). Of these, 24 (5 who did not answer most of the questions, 1 with surgery for rotator cuff tears, and 18 with cervical spondylotic radiculopathy) were excluded, resulting in a total of 82 participants (47.3%) who were included in the analysis (Fig. 1). The total percentage of missing values in all 24 questions was 10.5% (216/1968), and they were supplemented by the multiple imputation method. The characteristics of the study population are summarized in Table 1.

Principal Component Analysis

A scree plot of eigenvalues provides a visual inspection in which one component was retained according to where the slope levels off (Fig. 2). Through the principal component analysis, NRS variables were found to be reduced into one principal component with eigenvalues >1. The four variables for neck pain, upper limb pain, upper limb dysesthesia, and leg pain/dysesthesia cumulatively explained 67% of pain data variance and were considered candidate variables in the subsequent regression model. The principal component showed a high internal consistency ($\alpha = 0.831$).

Table 1
Characteristics of the Study Population (n = 82)

Variable	
Gender (n of female), (%)	30 (36.6)
Age (years), mean (SD)	67.7 (12.1)
Causes of degenerative cervical myelopathy (n), (%)	
Spondylosis	61 (74.3)
Disc herniation	4 (4.8)
Ossification of the posterior longitudinal ligamentum	17 (20.7)
Surgery (n), (%)	
Laminoplasty	50 (61.0)
Fusion	32 (39.0)
Days after surgery (days), mean (SD)	769.3 (295.8)
NDI (0–50), mean (SD)	9.46 (7.4)
NRS for neck pain (0–10), mean (SD)	1.83 (2.2)
NRS for upper limb pain (0–10), mean (SD)	2.60 (2.2)
NRS for upper limb dysesthesia (0–10), mean (SD)	2.96 (2.4)
NRS for leg pain and dysesthesia (0–10), mean (SD)	2.04 (2.2)
PSEQ (0–60), mean (SD)	39.2 (12.5)

SD = standard deviation; NDI = Neck Disability Index; NRS = Numerical Rating Scale; PSEQ = Pain Self Efficacy Questionnaire.

Table 2
Result of the Hierarchical Multiple Regression Analysis on Disability (n = 82)

Variables	Step 1 (B)	Step 2 (B)	Step 3 (B)
Gender	3.276[a]	3.162 [a]	3.388[b]
Age	-0.028	-0.034	-0.048
Pain	3.802 [b]	3.403 [b]	3.574 [b]
PSEQ		-0.223 [b]	-0.229 [b]
Age*Gender			-0.201 [a]
Pain*Gender			-3.749 [b]
PSEQ*Gender			-0.304 [b]
R^2	0.306	0.445	0.571
ΔR^2	0.306	0.138	0.127

[a] $p < 0.05$.
[b] $p < .01$.PSEQ = Pain Self Efficacy Questionnaire.

Hierarchical Multiple Regression Analysis

The results of the hierarchical multiple regression models testing the independent associations between DCM patients' biologic factors, psychosocial factors, and interaction terms on disability are shown in Table 2. All the VIF values which were <5 indicated that there was no multicollinearity. In step 1, biologic factors, which were age, gender, and pain, were included as independent variables. The hierarchical linear regression results showed that patients' biologic factors explained 30.6% of disability variance. Gender ($B = 3.276$; $p < .05$) and pain ($B = 3.802$; $p < .01$) had a significant positive association with disability. In step 2, the sum score of the PSEQ measured the psychosocial factors were included as independent variables. The results showed that the PSEQ explained an additional 13.9% of disability variance. Gender ($B = 3.162$; $p <.05$), and pain ($B = 3.403$; $p < .01$) had a significant positive association with disability. PSEQ ($B = -0.223$; $p < .01$) was significantly negative associated with disability. In step 3, interaction terms, which were age and gender, pain and gender, and PSEQ and gender, were included as independent variables. The results of hierarchical linear regression showed that interaction terms explained an additional 12.6% of disability variance. Gender ($B = 3.388$; $p < .01$), and pain ($B = 3.574$; $p < .01$) was significantly positive associated with disability. PSEQ ($B = -0.229$; $p < .01$), age and gender ($B = -0.201$; $p < .05$), pain and gender ($B = -3.749$; $p < .01$), and PSEQ and gender ($B = -0.304$; $p < .01$) had a significant negative association with disability. According to the simple slope test, the model with +1SD (women) showed weaker associations of pain with disability and stronger associations of age and PSEQ with disability than

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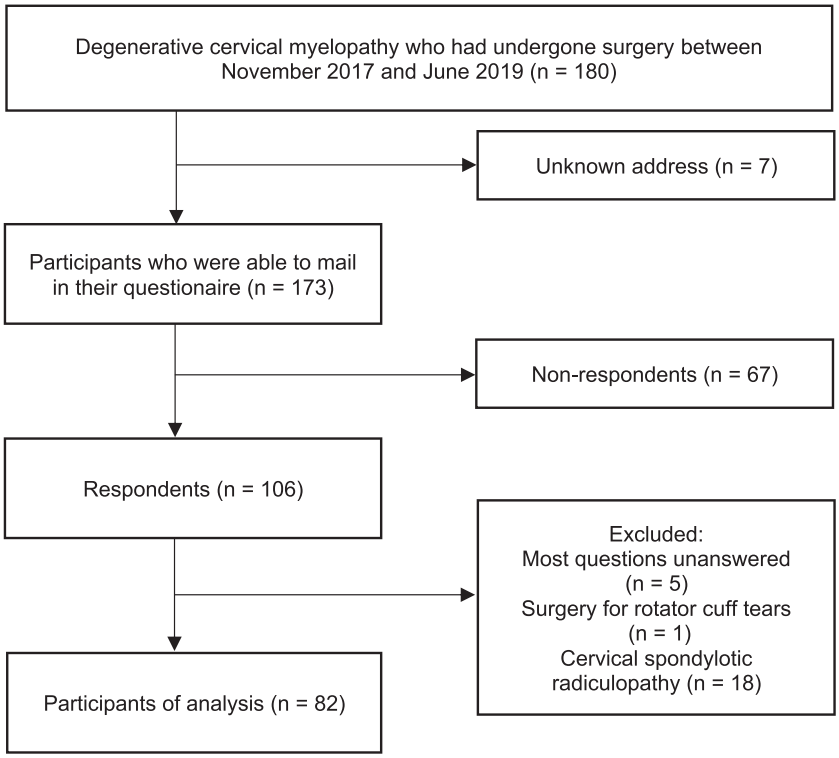

Figure 1. Flowchart of the participants.

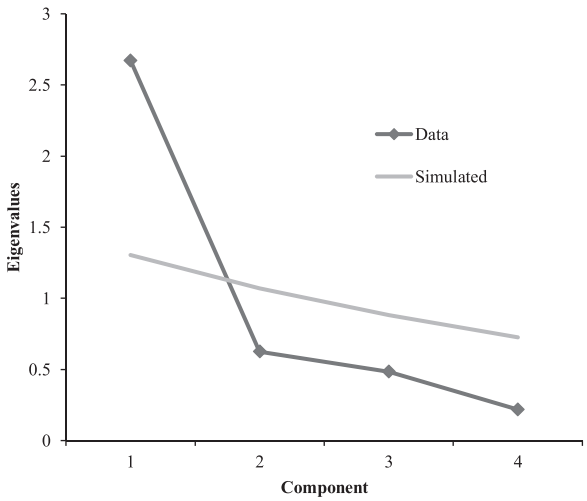

Figure 2. Scree plot of principal component analysis.

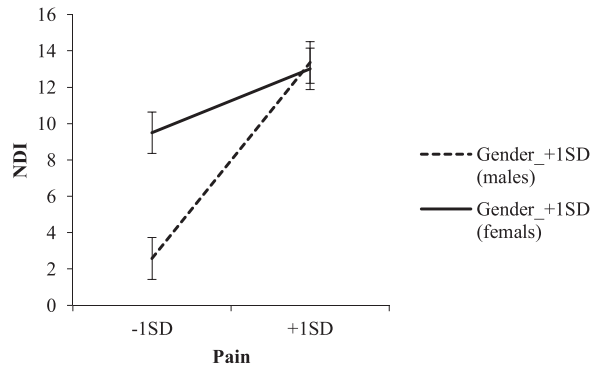

Figure 3. Simple slope plot of interaction between pain and gender on disability (n = 82). Model with +1SD (women) indicate weaker positive associations of pain with disability than the model with −1SD (men). NDI = Neck Disability Index.

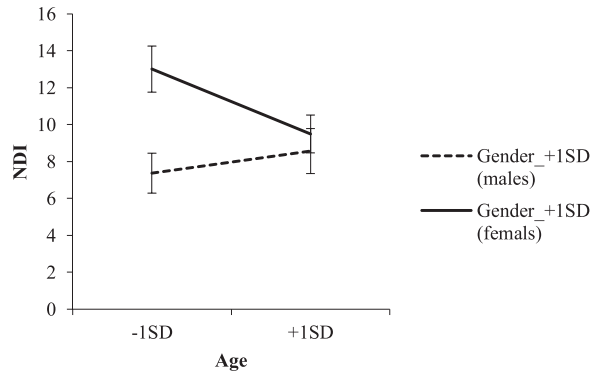

Figure 4. Simple slope plot of interaction between age and gender on disability (n = 82). Model with +1SD (women) indicate stronger negative associations of age with disability than the model with −1SD (men). NDI = Neck Disability Index.

the model with −1SD (men). These interactions were graphed in Figures 3 through 5. This final model explained 57.1% of the variance in disability of participants.

Discussion

This study was the first to investigate the direct and interactive effects of pain self-efficacy and gender on disability in postoperative people with DCM.

We found, by hierarchical linear regression that interaction terms between pain self-efficacy and gender affect postoperative disability in patients with DCM. Our conclusions are consistent with many previous studies in that lower pain self-efficacy is as-

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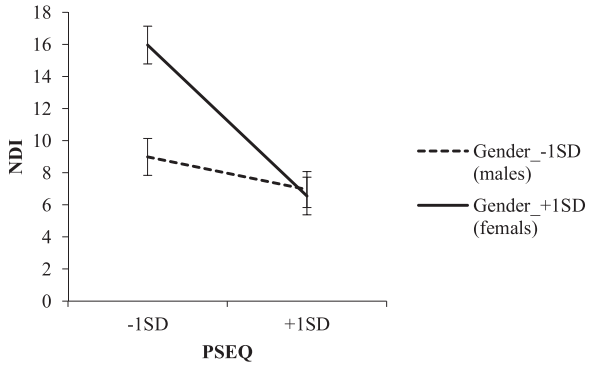

Figure 5. Simple slope plot of interaction between PSEQ and gender on disability (n = 82). The model with +1SD (women) indicate stronger negative associations of PSEQ with disability than the model with −1SD (men). NDI = Neck Disability Index; PSEQ = Pain Self Efficacy Questionnaire.

sociated with greater disability (Miki et al., 2021; Wylde et al., 2012). Therefore, the influence of gender should be considered in fully understanding the relationship between disability and pain self-efficacy in patients with DCM after surgery. This important finding could be a better guide for postoperative management strategies for people with DCM from a biopsychosocial perspective. Mean pain/dysesthesia intensity in this population ranged from 1.83 to 2.96, similar to the results of previous cohort studies reporting long-term results over 1 year after cervical spine surgery (Chang, Kim, & Choi, 2017; Gulati et al., 2021). Pain/dysesthesia was considered mild, but pain self-efficacy was low, which affected the greater disability independent of biologic factors such as pain. The association between lower pain self-efficacy and greater disability regardless of pain aligns with existing studies albeit in different cohorts (Miki et al., 2021). However, applicable in cases of mild pain in people with DCM after surgery, our findings might not be generalizable to those with more severe pain.

Pain self-efficacy has been consistently found to be a protective factor against psychological distress and disability. Conversely, low pain self-efficacy may lead to a vicious cycle, as shown by the fear-avoidance model, leading to chronicity. A previous study of 184 patients with chronic low back pain completed measures for pain intensity, disability, pain self-efficacy, and fear of movement at baseline and 12 months after the onset of chronic low back pain (Costa Lda, Maher, McAuley, Hancock, & Smeets, 2011). As a result, pain self-efficacy is a more critical factor for disability than fear of movement. Moreover, a previous study suggested that, with increasing levels of self-efficacy, pain intensity's direct effect on depressive symptoms and its indirect effect on depressive symptoms via catastrophizing were both reduced in a dose-dependent manner in patients with chronic pain (Cheng et al., 2018). Thus, pain self-efficacy may be a key aspect in implementing the management of DCM after surgery for preventing chronicity.

Interestingly, the simple slope test showed that the −1SD (female) model had a weaker association between pain and disability and a stronger association between pain self-efficacy and disability than the −1SD (male) model. Therefore, the findings of this study supported the hypotheses that female gender was associated with the influence of pain self-efficacy on disability. Previous studies have reported that depression and anxiety, associated with increased pain and other physical symptoms, were more common in women than in men (Salk et al., 2017). Meints et al. (2017) reported that female participants exhibited lower pain tolerance than male participants, and mediation analysis showed that these gender differences were mediated by the rumination component of catastrophizing (Meints et al., 2017).

Furthermore, La Touche et al. (2019) reported that in patients with chronic low back pain, and as well as higher disability, fear avoidance beliefs, fear of movement, and pain catastrophizing, the group with low pain self-efficacy had a higher proportion of women than the group with high pain self-efficacy (La Touche et al, 2019). Taken together, pain self-efficacy and gender interaction effects may reflect the previously reported female characteristics being more susceptible to cognitive emotional factors than those of men. On the other hand, there are reports that contradict them (Edwards et al., 2000; Robinson et al., 2005). Robinson et al. (2005) reported that anxiety was linked to self-reported and induced low back pain for men, but not for women (Robinson et al. 2005). Thus, there is currently no consensus on gender differences in the association between cognitive emotional factors and clinical symptoms (El-Shormilisy et al., 2015). Results from the present study suggest that there are important differences in the effect of pain self-efficacy on the disability of postoperative women and men with DCM; however, this may require careful interpretation. Therefore, further research using longitudinal or randomized controlled research designs to obtain more significant results would be needed to predict relationships and address this discrepancy.

The results of this study showed that interaction term with gender was associated with disability postoperatively in patients with DCM, suggesting that the association between age and disability may differ by gender. Generally, older age is associated with more severe disability due to increased cervical degenerative changes in DCM (Grodzinski et al., 2021). However, the simple slope test showed that women had stronger negative associations of age with disability than men. This may not be consistent with the general features of DCM, which is a degenerative disease. A number of studies focused on the age of patients with DCM (Grodzinski et al., 2021). Reported gender differences highlighted the relevance of considering a gender-related perspective in DCM research.

Implications for Nursing Education, Practice, and Research

As monitoring of pain self-efficacy in people with DCM after surgery may aid in the modification of postoperative management, nurses should assess pain self-efficacy. In particular, a preliminary screening of women would be recommended based on our results that female are more susceptible to pain self-efficacy than men. Furthermore, nurses may have to deal with low self-efficacy in patients, if necessary. Self-management support for chronic pain diseases is one of the effective interventions to increase pain self-efficacy (Elbers et al., 2018). There is clear evidence that changes in patient skills and behavior in self-management can be achieved with professional support (Panagioti et al., 2014). However, although nurses often provide interventions with self-management support, previous studies have reported that nurses are not adequately skilled to fulfill the role of self-management support (Wuyts et al., 2021). Appropriate training of nurses to implement self-management support is concluded to be a better predictor of achieving successful clinical outcomes than age or experience (Massimi et al., 2017). Therefore, establishing a global educational/training system will be a challenge for nurses in implementing the biopsychosocial model of care, not only for self-management support but also for other behavioral techniques to increase pain self-efficacy.

Limitations

This study has limitations that need to be acknowledged. First, the large variation in the days after surgery among patients,

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and two methods of surgery were included. These potential confounders have not been statistically examined for their influence, which may limit the validity of this study and should be interpreted with caution. Second, other factors that may influence gender differences have not been considered. Previous studies have shown that multiple biopsychosocial mechanisms contribute to gender differences in pain, including sex hormones, endogenous opioid function, depression and anxiety, coping and catastrophizing of pain, and gender roles (Bartley & Fillingim, 2013), which have potential gender differences and can affect gender-related cognitive differences. Therefore, we suggest these variables to be included in future studies. Finally, this was a cross-sectional study; therefore, a causal relationship between pain self-efficacy and disability cannot be confirmed. However, the preliminary evidence from this study justifies the need for further research to validate the PSEQ score as a screening tool for cervical spine surgery.

Conclusions

In this study, we investigated by hierarchical linear regression whether pain self-efficacy and gender affect disability postoperatively in patients with DCM. Overall, lower pain self-efficacy was independently associated with greater disability, regardless of pain intensity. In particular, women were shown to be more susceptible to pain self-efficacy than men. Therefore, focusing on improving pain self-efficacy may be an effective strategy in postoperatively treating patients with DCM.

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