Original Article

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Health-Related Quality of Life Is Associated With Pain, Kinesiophobia, and Physical Activity in Individuals Who Underwent Cervical Spine Surgery

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Objective: To determine the association between health-related quality of life (HRQOL) and neck pain, kinesiophobia, and modalities of physical activity in individuals with postoperative degenerative cervical myelopathy and radiculopathy (DCM/R) because postoperative pain after cervical spine surgery is likely to persist, causing kinesiophobia and avoidance of physical activity.

Methods: A questionnaire was distributed to 280 individuals with DCM/R. The questionnaire comprised the following four items: HRQOL (EuroQol 5-dimensions 5-level), neck pain (numerical rating scale [NRS]), kinesiophobia (11-item Tampa Scale for Kinesiophobia [TSK-11]), and physical activity (paid work, light exercise, walking, strength training, and gardening). Hierarchical multiple regression analysis was performed using the NRS, TSK-11, and physical activity as independent variables.

Results: In total, 126 individuals provided analyzable responses (45.0%). After including the NRS score as an independent variable to the multiple regression equation for participants' background, the independent rate of the regression equation significantly improved by only 4.1% (R^2=0.153). The addition of the TSK-11 score significantly improved this effect by 11.1% (R^2=0.264). Finally, the addition of physical activity also significantly improved the explanatory rate by 9.9% (R^2=0.363).

Conclusion: Neck pain, kinesiophobia, and physical activity (specifically paid work and walking) were independently associated with HRQOL in individuals with postoperative DCM/R.

Keywords: Quality of life, Neck pain, Kinesiophobia, Execise, Motor activity

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INTRODUCTION

The annual prevalence of neck pain, which exceeds 30% [1], has a substantial socioeconomic impact. Degenerative cervical myelopathy and radiculopathy (DCM/R) is one of the diseases with neck pain as a major symptom, and it includes cervical spondylosis, ossification of the posterior longitudinal ligament, and disc herniation [2].

Neck pain is a factor that negatively affects health-related quality of life (HRQOL) [3], which is one of the treatment outcomes [4]. Similarly, a negative association between pain and HRQOL has been found in other pain-induced diseases [5-8].

Eliminating pain is the first measure for improving HRQOL; however, if pain cannot be eliminated, other approaches should be developed. Although cervical surgery is indicated for moderate-to-severe DCM/R, neck pain also persists even postoperatively [9], requiring an approach with a target other than pain.

The fear-avoidance model (FAM) is a framework for improving HRQOL in DCM/R from perspectives other than pain. It conceptualizes a vicious cycle where pain generates fear of movement or kinesiophobia and consequently induces the avoidance of physical activity, resulting in disability [10]. While pain relief remains crucial, the reduction of kinesiophobia and improvement of physical activity may also possibly play substantial roles in enhancing HRQOL, as suggested by the FAM framework. Several reports, although not in the context of DCM/R, have indicated that kinesiophobia [11,12] and physical activity [13,14] are associated with HRQOL. However, whether kinesiophobia and physical activity are independently associated with HRQOL has not yet been addressed. Therefore, bridging this research gap is critical to devising strategies to optimize HRQOL in postoperative patients with DCM/R, considering both kinesiophobia and physical activity.

This study aimed to determine whether neck pain intensity, kinesiophobia, and modalities of physical activity are independently associated with HRQOL in individuals with postoperative DCM/R and evaluate their strength if an association exists. We hypothesized that the intensity of neck pain, kinesiophobia, and modalities of physical activity would be independently related to HRQOL in individuals with postoperative DCM/R. Therefore, this study will provide a valuable resource for treatment strategies to improve HRQOL in individuals with postoperative DCM/R since kinesiophobia and physical activity are modifiable factors [15].

METHODS

Study design and ethical considerations

This study was part of a mailed survey of individuals with postoperative DCM/R (Sapporo Maruyama Study), and a secondary analysis was conducted with objectives different from those previously reported [16]. The sample size required for the multiple regression analysis of this study, according to G*Power 3.1 (Heinrich-Heine-Universität Düsseldorf), was 127 patients with medium effect size (f^2=0.15), a significance level of 0.05, power of 0.80, and 12 independent variables described.

The study was conducted following the principles of the Declaration of Helsinki. Approval was obtained from the Ethical Review Committee of Sapporo Maruyama Orthopedic Hospital before conducting the study (approval number: 35). The study's explanation and a research participation consent form were enclosed with the questionnaire, and the participants were informed to sign the consent form if they were willing to participate.

Participants

This study's inclusion criteria were as follows: (1) individuals aged at least 20 years (since 20 years was the minimum age to provide independent informed consent for participation in studies in Japan at that time); (2) those diagnosed with DCM/R by a spine surgeon based on clinical and radiological findings and who had undergone surgery for DCM/R between December 2017 and June 2021 at Sapporo Maruyama Orthopedic Hospital; and (3) those who did not receive personal care because of cognitive decline. The diagnosis of DCM/R was made by specialists in spine surgery based on clinical and radiological findings. Surgery was indicated for patients whose symptoms did not improve with conservative treatment, or whose motor dysfunction or pain greatly interfered with their daily life. Decompression with fixation was chosen when radiological findings showed dynamic instability of the cervical spine or severe compression of the cervical spinal cord and/or nerve roots, while decompression (laminoplasty) was chosen in other cases. Thus, decompression with fixation was preferred when the disease was severe. Individuals with cervical spine fractures and dislocations, spinal cord tumors, previous cervical spine surgery, and a diagnosis of psychiatric or neurological disease (e.g., multiple sclerosis and cerebrovascular disease) were excluded.

In total, 293 individuals who met the inclusion criteria and did not meet the exclusion criteria were selected from the Sapporo Maruyama Study Database. The questionnaire was mailed to all participants in July 2022, i.e., at least 1 year postoperatively. However, 13 participants (4.4%) had unknown addresses; therefore, we finally mailed the questionnaire to 280 individuals.

Assessment items

Physical function

Physical function was assessed using the Japanese version of the neck disability index (NDI), which shows high internal consistency [17]. The NDI is a 10-item questionnaire, where each item scored from 0 to 5 points. Therefore, the possible scores range from 0 to 50, where higher scores indicate lower physical function.

HRQOL

EuroQol 5-dimensions 5-level (EQ5D) is recommended for measuring HRQOL in individuals after spinal surgery [18]. A utility value (EQ5D index value) ranging from 0 "a state as bad as being dead" to 1 "full health" is calculated as an overall measure of HRQOL [19].

Neck pain

An 11-point numerical rating scale (NRS) was used to assess the neck pain intensity, with 0 and 10 points defined as "no pain at all" and "unbearable pain," respectively. The NRS is a reliable scale for rating pain intensity at various sites, including the neck [20]. Respondents were asked to indicate the average intensity of their pain over 1 week.

Kinesiophobia

We used the 11-item Tampa Scale for Kinesiophobia (TSK-11), an abbreviated version of the Tampa Scale for Kinesiophobia, which is the mostly used instrument with confirmed internal consistency in individuals with degenerative diseases of the spine [21]. The scores range from 11 to 44, with higher scores indicating stronger kinesiophobia.

Modalities of physical activity

Respondents were asked how frequently they performed each of the five modalities of physical activity (paid work, light exercise, walking, strength training, and gardening) investigated by Higuchi et al. [22] in developing their model of HRQOL and physical activity in patients after lumbar spine surgery during the past month. We used a 5-point scale as follows: one point, "not at all;" two points, "irregularly;" three points, "once or twice a week;" four points, "three or four times a week;" and five points, "five or more times a week."

Statistical analysis

Imputing missing values is recommended because listwise deletion of missing values in the analysis reduces the reliability of the estimates [23]. Therefore, missing values were completed using the hot-deck method after excluding respondents who did not answer most of the questions or those who reported having pain on the EQ5D pain domain but did not report a score of ≥1 on the NRS and vice versa. The hot-deck imputation method is a technique where non-respondents (recipients) are matched with similar respondents (donors) and replaced by the observed values of the donors [24]. Hot-deck imputation method is used in various surveys, including the United States Census Bureau [25].

We performed hierarchical multiple regression analysis, which is a multiple regression analysis in which independent variables are entered in several steps and is used to assess the extent to which the additional independent variables contribute to the improvement of the model [26], using the EQ5D index as the dependent variable. In step one, sex (0, male; 1, female), age, surgical technique (0, decompression; 1, decompression and fixation) duration of postoperative days, and NDI were used as the independent variables. In step two, the NRS score was added as an independent variable 2; the TSK-11 score was added in step three; and in step four, paid work, light exercise, walking, strength training, and gardening were added. Each time an independent variable was added, we assessed whether the model improved and subsequently determined the final model. The referred statistics are the changes in F (ΔF) and R^2 (ΔR^2) values; if the F-value is significantly larger, the model is judged to have been improved by the additional independent variables. Finally, the regression coefficients for the final model were obtained.

Statistical analysis was performed using R version 4.2 (R Foundation), with a significance level of p=0.05.

RESULTS

A questionnaire was mailed to 280 individuals who underwent surgery for DCM/R more than a year earlier, and 169 (60.4%) responded. Among these, 43 individuals (41 individuals who did not respond to most of the questions or reported having pain on the EQ5D but did not report >1 point on the NRS and vice versa, and 2 who underwent shoulder or ankle joint surgery) were excluded, leaving 126 (45.0%) in the analysis (Fig. 1). The mean age of the eligible individuals was 65.0±12.2 years, and 84 and 42 were males and females, respectively (Table 1).

We collected 22 item responses (EQ5D, five items; NRS, one item; TSK-11, 11 items; and physical activity, five items) from each study participant. Therefore, 2,772 items were collected from 126 participants in the analysis. Of these, 21 items (0.8%) were missing data. These 21 missing values were obtained by using the hot-deck method. Table 2 summarizes the basic statistics of the assessed items after the completion of missing values.

The step-two model, with the addition of the NRS score, showed ΔF of 5.690 (p=0.019) and ΔR^2 of 0.041, indicating that the NRS score significantly improved the explanatory rate of the model by 4.1% compared with the step-one model. Similarly,

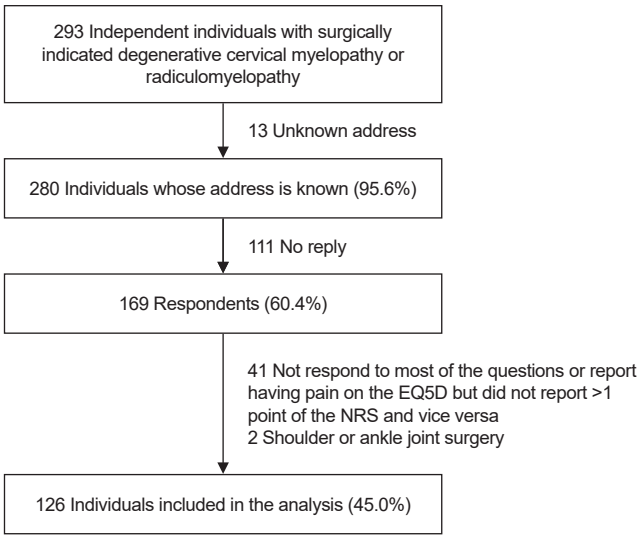

Fig. 1. Flow chart of the study participants. EQ5D, EuroQol 5-dimensions 5-level; NRS, numerical rating scale.

the TSK-11 score significantly improved the explanatory rate by 11.1% in the step-three model compared with the step-two model (ΔF=17.874, p<0.001). Finally, physical activity significantly improved the rate of explanation by 9.9% in the step-four model compared with the step-three model (ΔF=3.497, p=0.006; Table 3).

Table 4 presents the partial regression coefficients of the multiple regression equations obtained in step four of the hierarchical multiple regression analysis. The partial regression coefficients (t-values) for the NRS score, TSK-11 score, paid work, light exercise, and walking were -0.206 (-2.401), -0.275 (-3.494), 0.273 (2.870), -0.179 (-1.986), and 0.233 (2.513), respectively.

DISCUSSION

Main finding

Here, we examined whether neck pain intensity, kinesiophobia, and physical activity are independently associated with HRQOL in individuals with postoperative DCM/R based on the FAM and evaluated their strength if an association exists. This study's results showed that neck pain, kinesiophobia, and physical activity, such as paid work and walking, were independently associated with HRQOL to the same extent in individuals with postoperative DCM/R, which confirms our hypothesis.

Characteristics of the study participants

In this study, the mean NRS score for neck pain and EQ5D index of the participants were 3.0 and 0.738 points, respectively. A study that followed the postoperative course of patients who underwent cervical spine surgery showed that the NRS score for neck pain and EQ5D index were approximately 3 and 0.5 points, respectively, at 2 years postoperatively, with stable values at 1 and 2 years [26]. HRQOL was better among our study participants, although the neck pain intensity was similar between our study participants and those of Revesz et al.'s [27] study. HRQOL was also better in our study participants than in those

Table 1. Characteristics of the analyzed individuals

Characteristic	Value (n=126)
Age (yr)	65.0±12.2 (29–91)[a]
Sex	
Male	84 (66.7)
Female	42 (33.3)
Diagnosis	
Spondylotic myelopathy	63 (50.0)
Spondylotic radiculopathy	38 (30.2)
Ossification of the posterior longitudinal ligament	17 (13.5)
Disc herniation	8 (6.3)
Surgical technique	
Decompression	64 (50.8)
Decompression with fixation	62 (49.2)
Duration (day after surgery)	776.6±263.1 (388–1,326)[a]
Neck disability (point)	12.0±9.9 (0–50)[b]

Values are presented as number (%), [a]mean±standard deviation (minimum–maximum), or [b]median±quartile deviation (minimum–maximum).

Table 2. Basic statistics of the assessed items (n=126)

Item (range)	Median	Quartile deviation	Minimum	Maximum
EQ5D index (0–1 point)	0.74	0.081	0.164	1.000
NRS (0–10 points)	2	2.0	0	10
TSK-11 (11–44 points)	25	3.0	11	43
Paid work (1–5 points)	2.5	2.0	1	5
Light exercise (1–5 points)	2	1.4	1	5
Walking (1–5 points)	2	1.0	1	5
Muscle training (1–5 points)	1	0.5	1	5
Gardening (1–5 points)	1	0.5	1	5

EQ5D, EuroQol 5-dimensions 5-level; NRS, numerical rating scale; TSK-11, 11-item Tampa Scale for Kinesiophobia.

in other reports 1 year after cervical spine surgery [28]. However, the HRQOL of our study participants was lower than that of the general population, as the general population's mean EQ5D index was 0.83 points, even for individuals aged >75 years [29]. The factors contributing to better postoperative HRQOL of the participants in our study are unknown, and one factor for this may be our inclusion of individuals with DCM/R for >1 year; therefore, we included those with DCM/R for up to 3 years.

Table 3. Results of the model evaluation from steps 1 to 4 in the hierarchical multiple regression analysis (n=126)

Step	Independent variable	R^2	ΔR^2	ΔF	p-value
1	(Intercept) Sex Age Surgical technique Duration NDI	0.112	0.112	3.026	0.013*
2	Step 1 + NRS	0.153	0.041	5.690	0.019*
3	Step 2 + TSK-11	0.264	0.111	17.874	<0.001***
4	Step 3 + Paid work Light exercise Walking Muscle training Gardening	0.363	0.099	3.497	0.006**

Dependent variable: EuroQol 5-dimensions 5-level.
NDI, neck disability index; NRS, numerical rating scale; TSK-11, 11-item Tampa Scale for Kinesiophobia.
*p<0.05, **p<0.01, and ***p<0.001.

Relationships between HRQOL and neck pain, kinesiophobia, and physical activity

We demonstrated that neck pain intensity, kinesiophobia, and physical activity were independently associated with HRQOL in patients with postoperative DCM/R. This finding supports the use of the FAM to better understand the relationship between HRQOL and neck pain in patients with postoperative DCM/R.

A report on contemporaneous improvements in neck pain and HRQOL postoperatively [4] suggested an association between neck pain and HRQOL. We hypothesized that pain interacts with various issues, such as sleep disruption, emotional disturbance, and reduced labor productivity (presenteeism), which directly or indirectly reduce HRQOL. Therefore, the HRQOL model that focuses on kinesiophobia and physical activity was developed in this study; however, there is room to improve and expand the model.

Kinesiophobia and physical activity were independently associated with HRQOL and neck pain in this study. A systematic review indicated that kinesiophobia is a psychosocial factor involved in the HRQOL of patients with chronic low back pain [30]. Kinesiophobia has also been reported as a risk factor for poor HRQOL in patients after undergoing hip surgeries [31]. Therefore, generalizing that kinesiophobia caused by pain re-

Table 4. Partial regression coefficients and t-values in the model for step 4 in the hierarchical multiple regression analysis (n=126)

Independent variable	Partial regression coefficient	Standardized partial regression coefficient	t-value	p-value
(Intercept)	0.973	-	6.850	<0.001***
Sex	0.018	0.056	0.696	0.488
Age	0.000	-0.001	-0.014	0.989
Surgical technique	0.052	-0.173	1.995	0.048*
Duration	0.000	0.010	0.128	0.898
NDI	-0.001	-0.066	-0.792	0.430
NRS	-0.009	-0.206	-2.401	0.018*
TSK-11	-0.007	-0.275	-3.494	0.001**
Walking	0.025	0.233	2.513	0.013*
Light exercise	-0.018	-0.179	-1.986	0.049*
Muscle training	-0.019	-0.139	-1.565	0.120
Gardening	0.004	0.032	0.397	0.692
Paid work	0.022	0.273	2.870	0.005**

Dependent variable: EuroQol 5-dimensions 5-level.
NDI, neck disability index; NRS, numerical rating scale; TSK-11, 11-item Tampa Scale for Kinesiophobia.
*p<0.05, **p<0.01, and ***p<0.001.

sulting from bone and joint diseases, regardless of the disease, may have a negative impact on HRQOL. However, the relationship between pain intensity and kinesiophobia, a psychosocial variable, is not necessarily unidirectional.

Kinesiophobia is the largest factor associated with HRQOL, followed by paid work, walking, neck pain intensity, and light exercise. Paid work is a measure to improve physical activity because performing one's job duties or commuting to work involves physical activity, i.e., work-related physical activity. However, work-related physical activity was reported to differ between white- and blue-collar workers [32]; therefore, as in this study, the frequency of performing paid work alone could not accurately represent the amount of physical activity. Even if eliminating neck pain is difficult, interventions to reduce kinesiophobia and promote physical activity, such as paid work and walking, can be modified, indicating that these factors may be effective in improving HRQOL. This study did not measure the amount of physical activity using a tri-axial accelerometer or an international standard questionnaire but only asked about the modalities and the frequencies of physical activity they usually perform; therefore, whether paid work and walking are related to HRQOL dose-dependently remains unclear. Assessing the quantitative and qualitative impact of physical activity on HRQOL will contribute to further understanding and effective support of HRQOL in individuals with DCM/R who underwent surgery. Finally, contrary to the hypothesis, the conduct of light exercise was found to be negatively associated with HRQOL. The etiology of this cannot be addressed in this study. However, it was hypothesized that those individuals who had neck complaints tried to move their necks more than those who did not have any complaint.

Strengths and limitations of this study

This is the first study to examine factors associated with postoperative HRQOL in individuals with DCM/R based on the FAM framework. The knowledge obtained through this study to better understand the relationship between postoperative HRQOL and neck pain can contribute to developing postoperative rehabilitation strategies.

However, this study had some limitations. First, the rate of questionnaire collection was low. Consequently, a low response rate can lead to sampling bias, raising concerns regarding the robustness of the results. Second, as previously mentioned, the physical activity levels were not quantified. Therefore, reporting past performance does not rule out recall or social desirability biases, and the quantitative relationship between physical activity and HRQOL cannot be determined. Because of these methodological limitations, this study's results should interpreted with caution, and our research should be developed to clarify the quantitative and qualitative relationship between physical activity and HRQOL. Third, this was a cross-sectional study. Although this study hypothesized a causal relationship based on the FAM, determining the causal relationship between HRQOL and its associated factors was difficult. Therefore, future interventional studies on kinesiophobia and physical activity should be designed to establish a causal relationship. Finally, HRQOL was assessed as a unidimensional construct. We used the EQ5D index value that operationally defines scores of 0 as "a state as bad as being dead" and 1 as "full health." The 36-item Short Form Survey uses a two-factor model of physical and mental health [33]. Therefore, further analysis using HRQOL substructures may provide additional information that requires validation.

In conclusion, this study reveals that the reduction of neck pain, reduction of kinesiophobia, and promotion of physical activity, such as paid work and walking, may be effective intervention strategies to improve HRQOL in individuals with postoperative DCM/R.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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AUTHOR CONTRIBUTION

Conceptualization: Higuchi D, Kondo Y. Methodology: Kondo Y. Formal analysis: Higuchi D. Funding acquisition: Higuchi D. Project administration: Higuchi D. Visualization: Higuchi D. Writing – original draft: Higuchi D. Writing – review and editing: Watanabe Y, Miki T. Approval of final manuscript: all authors.

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