



Original Article

Patterns of physical activity and exercise after lumbar surgery among Japanese patients with lumbar spinal stenosis

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Abstract. [Purpose] The purpose of this study was to assess the feasibility of classifying the patterns of physical activity and exercise after surgery for lumbar spinal stenosis in Japanese patients and describe the characteristics of the patient groups. [Participants and Methods] We evaluated Japanese patients diagnosed as having lumbar spinal stenosis and underwent surgery. The frequencies of the 15 types of physical activity and exercise recommended in Kenko Nippon 21 (Japanese policy for health promotion) were investigated by mail. The study included 102 respondents (median age, 69 years [range, 34–88 years]; 55 males and 47 females). A hierarchical cluster analysis was used for grouping according to the physical activity and exercise patterns. The Holm method and residual analysis were used for comparisons of the frequencies of the physical activity and exercise patterns and basic demographics among the groups. [Results] Three clusters, namely clusters A (younger), B (frail older), and C (active older), were identified from the dendrogram. The participants in cluster A frequently performed paid work. In cluster B, the frequencies of all the physical activity and exercise patterns were low. The older people in cluster C regularly performed stretching/light-intensity exercises, walking, muscle-strengthening exercises, and house and garden maintenance tasks. [Conclusion] We found that the physical activity and exercise after lumbar surgery in Japanese patients could be divided into three patterns.

Key words: Lumbar spinal stenosis, Health promotion, Physical activity

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INTRODUCTION

The population in Japan is aging, with the average life expectancy increasing while the birth rate is decreasing. Accordingly, the burden of cost of social security is increasing. To address this issue, the Japanese Ministry of Labor, Health, and Welfare formulated the Kenko Nippon 21 (Healthy Japan 21) in 2000 and mandated all 47 prefectures to promote health to increase health-related quality of life (HRQOL) and consequently decrease the social security cost. The first stage of the Kenko Nippon 21 was implemented from 2000–2012, and the second stage is in effect until 2022, with the following six dimensions set as targets: nutrition and dietary habits; physical activity (PA) and exercise (Ex); rest; alcohol drinking; tobacco smoking; dental and oral health. Unfortunately, many targets have not been accomplished, and thus, activities to achieve the targets of each dimension need to be promoted.

PA/Ex is one of the prospective approaches to health promotion. PA is positively associated with sleep quality^{1, 2)} and HRQOL among healthy older people^{3, 4)}. Further, PA/Ex intervention has been reported to have a positive effect on mobility and physical functioning among older people (≥65 years) with physical impairments⁵⁾ and frailty⁶⁾. PA is also significantly correlated with HRQOL, including in those aged <65 years⁷⁾. Moreover, PA is associated with various work-related factors

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such as low work ability⁸⁾, perceived stress at work⁹⁾, and receiving disability pension¹⁰⁾. A relationship between PA and back pain has also been established; workers with extremely high or low PA are more likely to complain of low back pain (LBP), while workers with moderate PA are the least likely to complain of LBP¹¹⁾. These results collectively support that health promotion through PA/Ex should be performed in both individuals with and without morbidity.

LSS is one of the most common spinal disorders among the middle-aged (45–64 years) and older people, thus making individuals with LSS appropriate targets for health promotion through PA/Ex. Additionally, people with LSS have health and social problems despite undergoing lumbar surgery. In Japan, approximately 3.65 million people have LSS¹²⁾. The common symptoms of LSS are low back pain, leg pain and dysesthesia, and muscle weakness in the legs. When conservative treatment is not effective and the LSS impairs the performance of activities for daily living due to pain and/or dysesthesia in the low back and/or the legs, patients undergo surgical treatment for symptom management¹³⁾. However, pain and/or dysesthesia do not always completely disappear after surgery¹⁴⁾. About 25% of postoperative LSS patients still report pain and/or dysesthesia and require medication¹⁵⁾. Accordingly, individuals with LSS have poorer HRQOL than healthy people even after undergoing¹⁶⁾. They also have a less than 50% probability of returning to work after surgery^{17, 18)}.

The Kenko Nippon 21 describes the characteristics of each life stage and highlights the importance of health promotion conforming to the life stage. Therefore, the targets of PA/Ex are separated into two by age: 20–64 years (young to middle age adults) and 65 years or older (older adults). Young to middle age adults often spend a considerable time working during the daytime, while older adults after retirement can use daytime according to their preference. Moreover, physical activity can be more varied among older people.

We wanted to understand the patterns of PA/Ex among individuals with LSS to develop PA/EX interventions that improve physical and mental function as well as HRQOL after lumbar surgery in these patients, particularly those who have chronic pain and/or dysesthesia. We hypothesized that the patterns of PA/Ex after surgery for LSS differ between Japanese people aged 20 years or older and should thus be separated according to the patient's life stage and style. In the current study, we aimed to assess the feasibility of classifying Japanese people according to the pattern of PA/Ex after surgery for LSS and, if the classification is successful, describe the characteristics of the different groups based on our classification.

PARTICIPANTS AND METHODS

This cross-sectional study was approved by the ethical committee of Sapporo Maruyama Orthopedic Hospital (approval number: 000025). The participants were individuals who were diagnosed with LSS and underwent surgical treatment between September 2017 and August 2018 in Sapporo Maruyama Orthopedic Hospital in Japan. Given that the pathology of LSS involves spinal and nerve root canal stenosis through intervertebral disc herniation, hypertrophy of the ligamentum flavum, hypertrophy of the facet joint, spondylolisthesis, osteophyte, and ectopic fat tissue, lumbar disc herniation were considered as subtypes of LSS in this study. Individuals aged less than 20 years and those whose current addresses were unknown were excluded.

We developed a set of questionnaires comprising three sections on demographic data, HRQOL using EuroQOL 5 dimensions 5-level (EQ-5D-5L), and 15 types of PA/Ex introduced in the Kenko Nippon 21 (See below for details). To combine the response data with the medical records of Sapporo Maruyama Orthopedic Hospital, respondents were asked to provide his/her name. After the questionnaire was developed, the addresses of people who met the inclusion criteria were extracted from the Sapporo Maruyama Orthopedic Hospital database and were distributed by mail in November 2019. Explanatory leaflets about this study, consent forms to participate in this study, and return envelopes were also enclosed. If they agreed to participate in the study, they were asked to return the answered questionnaire and the consent to participate in the study form to Sapporo Maruyama Orthopedic Hospital within 2 weeks of arrival. The returned questionnaires were tabulated by the authors and converted into electronic data.

Patient age was determined using the questionnaire, while data on gender, date of lumbar surgery, and operative methods were extracted from the medical records. The average intensities of LBP and pain and numbness of the legs for the previous month were assessed using the 11-point numerical rating scale (NRS), with 0 points defined as “no pain or numbness” and 10 points as “unbearable pain or numbness”. The NRS has been previously verified to be a reliable and valid scale for assessing pain intensity¹⁹⁾.

EQ-5D-5L was used to assess HRQOL. The EQ-5D-5L consists of five questions concerning mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Severities of these five dimensions are divided into five levels²⁰⁾. The construct validity of the EQ-5D-5L has been confirmed in patients with stroke²¹⁾ and osteoarthritis²²⁾. The EQ-5D-5L index scores, which were calculated by replies to the five questions, ranges from 0 to 1, with 0- and 1- points representing death and full healthy status, respectively²³⁾.

We evaluated the following 15 types of PA/Ex introduced in the Kenko Nippon 21: (1) paid works; (2) activities in the community and volunteers; (3) intellectual and cultural activities such as music, and art appreciation and hobbies; (4) stretching and light-intensity exercises; (5) walking; (6) muscle-strengthening exercises of the trunk and legs; (7) hiking, picnic, orienteering, and camping; (8) traveling and hosteling; (9) dancing (e.g., social dances, folk dances, classical Japanese dances, yoga and tai chi); (10) maintenance tasks of the house and garden including kitchen garden; (11) golf including ground golf, mini golf, and target-bird-golf; (12) gateball (Japanese croquet), bowling, and lawn bowling; (13) lawn and

table tennis; (14) billiards, quoits, darts, and frisbee; and (15) swimming, walking, dances, and underwater exercises. The frequencies of each PA/Ex for the previous month were investigated using the 5-point Likert scale (1: never; 2: irregular; 3: 1–2 days per week; 4: 3–4 days per week; 5: 5 days or more per week).

First, missing values were complemented using the multiple imputation method by chained equation. We set the number of substitutions at 10. Second, respondents were classified based on frequencies of PA/Ex using the hierarchical cluster (CL) analysis (dissimilarity index: the Euclidean distance; clustering method: the furthest neighbor method), and we assessed whether respondents could be categorized into three CLs using the dendrogram. If, as hypothesized, the dendrogram could classify the respondents into three clusters, the descriptive statistics values of scores of the assessed items were calculated in each group, and the scores were compared among the three groups using the Holm method for the ordinal and ratio variables and the residual analysis for the categorical variables.

The multiple imputation method was performed using R version 3.6 (Foundation for Statistical Computing, Vienna, Austria), while other statistical analyses were performed using HAD version 16.1²⁴). A probability level of 0.05 was considered statistically significant.

RESULTS

Questionnaires were sent to 176 individuals who underwent lumbar surgery more than 1 year earlier in Sapporo Maruyama Orthopedic Hospital, and the response rate was 59% (n=102). Three sets of questionnaires were returned because of unknown address. The median participant age was 69 years [range, 34–88 years], and 55 and 47 were male and female, respectively.

In total, 8/102 participants (7.8%) returned questionnaires with missing responses. The total percentage of missing values in all 23 questions was 0.6% (15/2346). These missing values were complemented using the multiple imputation method, and the absolute data of 102 respondents were used for the following analyses.

A dendrogram categorizing 102 participants into 25 clusters (CLs1-25) based on the frequency scores of the 15 types of PA/Ex is shown in Fig. 1. The dendrogram indicated three CLs according to the cut-off line. CLs 1 to 9, 10 to 17, and 18 to 25 were named as CLs A, B, and C, respectively. CLs A, B, and C comprised 40, 51, and 11 participants, respectively. The participant characteristics by CL are shown in Table 1. Participants in CL A were significantly younger (percentage of participants aged 65 years or older: 32.5% [13/40]) than those in CLs B (76.5% [39/51]) and C (81.8% [9/11]). CL A also included more men, had lower number of posterior interbody fusion, and higher EQ-5D-5L. Meanwhile, CLs B and C included a higher number of female and lower number of laminoplasty, respectively. There were no significant differences in the interval between surgery and NRS of LBP and leg pain and numbness among the three CLs.

The frequencies of PA/Ex in CLs A, B, and C are summarized in Table 2. We found significantly higher frequencies of paid work in CL A compared with CL B and C ($p<0.01$). There were significantly higher frequencies of intellectual and cultural activities in CL C versus CL B ($p<0.05$). There were also higher frequencies of stretching and light-intensity exercises, walking, and muscle-strengthening exercises in CL C than CL A and B ($p<0.01$). Moreover, maintenance tasks for the house and garden, including kitchen gardening were also higher in CL C than CL A and B ($p<0.05$). There were no higher frequencies of PA/Ex in CL B compared with CL A and C.

DISCUSSION

The first purpose of this study was to assess whether Japanese people could be classified based on the pattern of PA/Ex after surgery for LSS. Through the hierarchical CL analysis, we identified three groups (CLs A, B, and C). This classification met our hypothesis and supported the validity of making targets of PA/Ex at each life stage stipulated by the Kenko Nippon 21.

Behavioral characteristics of CL A included higher frequency of paid work compared with the other two CLs. Meanwhile, CL C showed higher frequencies of intellectual and cultural activities; stretching and light-intensity exercises; walking; muscle-strengthening exercises; and maintenance tasks of house and garden, including gardening. Unlike CLs A and C, the frequencies of all PA/Ex were low in CL B. These PA/Ex can be performed inside the house; thus, we considered stretching and light-intensity exercises, walking, muscle-strengthening exercises, and maintenance tasks of the house and garden as potential components of PA/Ex intervention programs. In contrast, sports and recreational activities, which needed more money and time, specific facilities, or colleagues, were not regularly performed in all CLs.

Many people in CL A (work-centered group) were aged less than 65 years, men, and had a higher HRQOL than the other CLs. The employment of individuals aged less than 65 years is legally protected, and government data show that the number of male full-time workers is more than 1.5 times higher than that of female workers in Japan. The EQ-5D-5L user guide shows that the EQ-5D-5L index scores of younger people are greater than those of older people. Moreover, it was reported that returning to working would positively influence the HRQOL²⁵), and that HRQOL and psychological distress in working people with coronary heart disease were better than in non-working people²⁶).

Participants in CLs B (non-active group) and C (active group) were mainly aged over 65 years. Although both CLs B and C were coetaneous, CL B included more females, while CL C had a lower rate of laminoplasty. The amount of PA based on the triaxial accelerometer in older Japanese females was found to be significantly lower than that of older men²⁷), and this

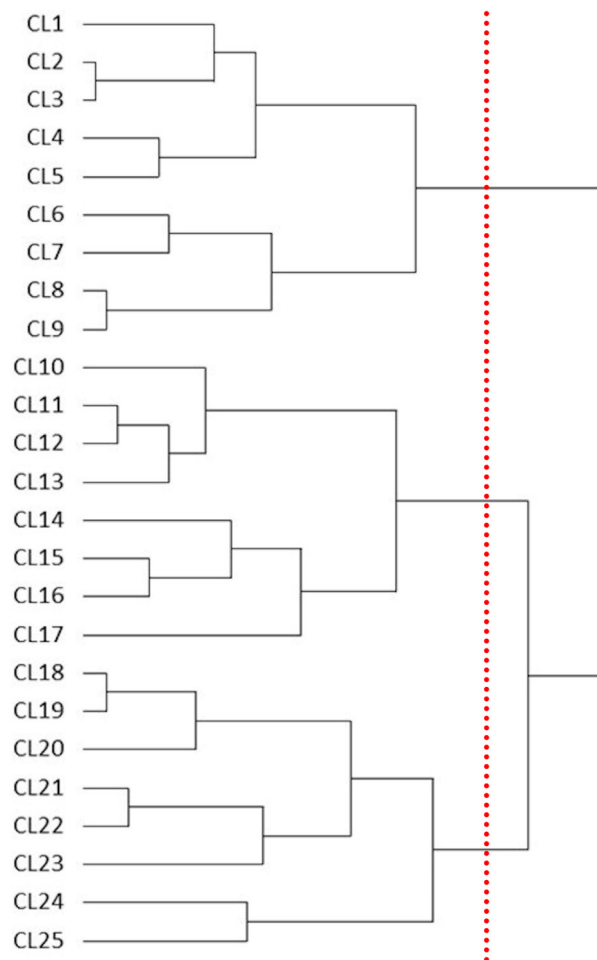


Fig. 1. Dendrogram clustering the 102 responders based on patterns of physical activities and exercises. This dendrogram was drawn after placing 102 responders into 25 clusters (CL 1–25). The dotted line is the cut-off line; three clusters were made: CL A, CLs 1–9; CL B, CLs 10–17; and CL C, CLs 18–25.

may have caused the higher number of older females in CL B in this study. The intensities of low back pain and leg pain/numbness did not significantly differ between the CLs B and C, but no participant in CL C has undergone laminoplasty to decompress the nerve root. This finding suggested that radiological findings of LSS in the CL C were more severe than those in CL B because decompression techniques such as laminoplasty and discectomy were frequently used in CL C, while instrumentation techniques, i.e., posterior interbody fusion, were frequently used in CL B. Although, the EQ-5D-5L index scores did not significantly differ between CLs B and C, we believe that this finding does not necessarily indicate that there was no association between PA/Ex and HRQOL. It was difficult to assess the relationship between PA/Ex and HRQOL by comparing only HRQOL between CLs B and C. CL B involved not only participants whose HRQOL was low due to low PA/Ex, but also those who did not want to perform PA/Ex because they had inadequate physical ability. Meanwhile, the CL C included not only people who succeeded in maintaining high HRQOL by doing regular PA/Ex, but also those who had yet to benefit from PA/Ex because they only started the interventions/activity.

The classification of PA/Ex after lumbar surgery in this study indicates that PA/Ex interventions should be individualized and modified according to the three patterns of PA/Ex: 1) more frequent paid work, 2) less frequent PA/Ex, and 3) more frequent daily PA such as walking, stretching/light exercise, and household tasks. First, workers (CL A) spend a high amount of time performing work-related tasks, and thus it is difficult to allow time for sports and recreation. Therefore, measures to increase the amount of PA should be provided at the work site^{28, 29)} considering the job type³⁰⁾. Second, older people with low frequency of PA/Ex (CL B), particularly females, are at risk of frailty³¹⁾. Appropriate PA/Ex by the older population, namely, stretching and light-intensity exercises, walking, muscle-strengthening exercises, maintenance tasks of house, and garden including kitchen gardening, at low frequencies and intensities are recommended as the first step. Combinations with cognitive interventions to motivate PA/Ex are promising³²⁾. Third, for older people with high frequency of PA/Ex (CL C), the recommendation is to increase intensity or time rather than frequency of common PA/Ex or introducing sports and

Table 1. Baseline clinicodemographic characteristics of the participants by cluster of physical activity and exercise

	Cluster A (n=40)	Cluster B (n=51)	Cluster C (n=11)
Age (years) [†]	59 ± 8.3 [34–86] ^a	72 ± 6.0 [40–88]	74 ± 3.3 [45–82]
Gender (male; female)	30 ^c ; 10 ^d	19 ^d ; 32 ^c	6; 5
Days after surgery [†]	572 ± 83.9 [396–759]	515 ± 98.8 [382–779]	552 ± 108.0 [410–773]
Operative methods			
Laminoplasty	14 (35.0%)	12 (23.5%)	0 (0%) ^e
Posterior interbody fusion [‡]	15 (37.5%) ^d	33 (64.7%)	9 (81.8%)
Discectomy	11 (27.5%)	6 (11.8%)	2 (18.2%)
NRS for low back pain [†]	0.5 ± 1.1 [0–5]	2 ± 1.5 [0–8]	2 ± 1.8 [0–6]
NRS for leg pain [†]	0 ± 1.0 [0–5]	1 ± 1.5 [0–7]	2 ± 1.5 [0–7]
NRS for leg numbness [†]	0 ± 1.0 [0–7]	1 ± 1.5 [0–8]	3 ± 2.3 [0–8]
EQ-5D-5L [†]	0.81 ± 0.14 ^b [0.48–1.00]	0.76 ± 0.08 [0.01–1.00]	0.70 ± 0.08 [0.51–1.00]

[†]Values are presented as mean (median) ± (quartile deviation) [range].

[‡]Anterior or posteriolateral fusions were combined as needed.

^ap<0.01 (vs. cluster B and C); ^bp<0.05 (vs. clusters B and C); ^csignificantly higher values from the adjusted standardized residuals (p<0.01); ^dsignificantly lower values from the adjusted standardized residuals (p<0.01); ^esignificant lower values from the adjusted standardized residuals (p<0.05).

NRS: numerical rating scale; EQ-5D-5L: EuroQOL 5 dimensions 5-level.

Table 2. Frequencies of physical activities and exercises by cluster

	Cluster A (n=40)	Cluster B (n=51)	Cluster C (n=11)
Paid work	5 ± 0 [1–5] ^a	1 ± 0 [1–2]	1 ± 0 [1–3]
Activities in the community and volunteers	1 ± 0 [1–2]	1 ± 0 [1–4]	1 ± 0.3 [1–5]
Intellectual and cultural activities	1 ± 0.5 [1–4]	1 ± 0.5 [1–4]	2 ± 1.3 [1–5] ^b
Stretching and light-intensity exercises	2 ± 1.1 [1–5]	2 ± 1.0 [1–5]	4 ± 0.5 [2–5] ^c
Walking	1 ± 0.5 [1–5]	2 ± 0.5 [1–5]	4 ± 0.5 [2–5] ^c
Muscle-strengthening exercises	1 ± 0.5 [1–5]	1 ± 0.5 [1–5]	4 ± 1.3 [1–5] ^c
Hiking, picnic, orienteering, and camping	1 ± 0 [1–2]	1 ± 0 [1–3]	1 ± 0 [1–1]
Dancing	2 ± 0.5 [1–2]	1 ± 0.5 [1–2]	1 ± 0.5 [1–2]
Traveling and hosteling	1 ± 0 [1–4]	1 ± 0 [1–3]	1 ± 0 [1–4]
Maintenance tasks of the house and garden	1 ± 0.5 [1–5]	2 ± 0.5 [1–5]	4 ± 1.8 [1–5] ^d
Golf	1 ± 0 [1–4]	1 ± 0 [1–3]	1 ± 0 [1–3]
Gateball, bowling, and lawn bowling	1 ± 0 [1–2]	1 ± 0 [1–3]	1 ± 0.3 [1–3]
Lawn and table tennis	1 ± 0 [1–3]	1 ± 0 [1–2]	1 ± 0 [1–1]
Billiards, quoits, darts, and frisbee	1 ± 0 [1–1]	1 ± 0 [1–1]	1 ± 0 [1–1]
Swimming and underwater exercise	1 ± 0 [1–3]	1 ± 0 [1–4]	1 ± 0 [1–4]

Values are presented as mean (median) ± (quartile deviation) [range]. ^ap<0.01 (vs. cluster B and C); ^bp<0.05 (vs. cluster B); ^cp<0.01 (vs. cluster A and B); ^dp<0.05 (vs. cluster A and B).

recreational activities. Although it is necessary to consider the background of the people as well as their preferences and economic and cultural background, the classification of PA/Ex in this study would help develop individualized programs for health promotion through PA/Ex among participants with LSS who underwent surgery.

This study has two major limitations. First, it is impossible to clarify the relationship between PA/Ex and HRQOL because this was a cross-sectional study. The effect of PA/Ex on HRQOL in individuals with high PA/Ex and low HRQOL was not evaluated because of the low intensity or short duration of PA/Ex. We intend to examine the internal structure of both CLs B and C to understand further the association between PA/Ex and HRQOL among older people who underwent lumbar surgery. Second, this study was conducted from late autumn to early winter; seasons and climates^{33,34} and area of residence (urban or rural)³⁵ are known to influence the amount and patterns of PA/Ex. Against these limitations, longitudinal studies, including intervention studies and comparative studies at multiple sites in different climatic and cultural backgrounds, can deepen and reinforce the findings of this study.

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Conflict of interest

There is no conflict of interest to be disclosed.

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