Influence of Sarcopenia on the Effect of Exercise Therapy for Elderly Patients with Chronic Low Back Pain

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Abstract:

Introduction: Sarcopenia, a condition characterized by decreased skeletal muscle mass, has increasingly been attracting attention in Japan, which has an aged society. The association between chronic low back pain (CLBP) and muscle mass is important. This study aimed to investigate the effect of exercise therapy for CLBP with or without sarcopenia.

Methods: This study was a prospective cohort study. Patients who were aged >65 years during 2017-2018 and had CLBP, with pain lasting >12 weeks and pain intensity being ≥3, were included in the study. The patients were divided into two groups: sarcopenia (S) and nonsarcopenia (NS) groups. The numerical rating scale (NRS) for pain intensity, Roland-Morris Disability Questionnaire (RMDQ), Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ), Hospital Anxiety and Depression Scale (HADS), trunk muscle strength, a European Quality of Life instrument, and an NRS of treatment satisfaction were assessed. All patients underwent a high-intensity exercise therapy during 2 weeks of hospitalization and were followed up for 1 and 3 months.

Results: Twenty-eight patients with CLBP were included. The prevalence rate of sarcopenia was 42.9%. The NRS and RMDQ scores and gait function were clinically improved at the end points in all patients with or without sarcopenia. Moreover, high treatment satisfaction was achieved. The quality of life, treatment satisfaction, psychological disorder subscale score of the JOABPEQ, and HADS score tended to be lower in the S group than in the NS group.

Conclusions: Our short-term exercise therapy was effective for low back pain, disability, and gait disturbance in elderly patients with CLBP with or without sarcopenia. However, the prevalence of sarcopenia was high in elderly patients with CLBP. Although low back pain and disability in patients in the S group were improved by exercise therapy, their quality of life and treatment satisfaction might be lower than those of patients without sarcopenia.

Keywords:

sarcopenia, chronic low back pain, physical therapy, quality of life, exercise

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Introduction

In the general population, 70%-85% of adults are believed to have experienced at least one episode of low back pain (LBP) during their lifetime[1]. In Japan, the prevalence rate of LBP is high, which is at 37.7% (men, 34.2%; women, 39.4%)[2]. Additionally, the LBP complaint ratio in 2013 was the worst for men and the second worst for women[3]. LBP can significantly reduce activities of daily living and quality of life (QoL). Moreover, LBP has become a global health problem because it leads to a decline in socioeconomic productivity. Nonspecific LBP, the specific cause of which cannot be identified using standard diagnostic techniques, accounts for approximately 85% of all LBP cases, and it can be caused by a variety of factors, such as age, stress, depression, family history of LBP, smoking habit, occupation, and lifestyle[4].

Recently, sarcopenia has drawn worldwide attention. The European Working Group on Sarcopenia in Older People defined sarcopenia as follows: "Sarcopenia is a syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength with a risk of adverse outcomes

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such as physical disability, poor quality of life and death"[5]. In Japan, where 27.7% of the population are aged >65 years, sarcopenia is becoming a concern[6]. Reports on the relationship between LBP and the muscles have indicated that LBP is related to lumbar extensor and multifidus muscle atrophy[7-12], the recurrence rate of LBP is related to impaired spinal stability due to muscle loss[13,14], and LBP is associated with the intramuscular fat of spinal extensors[13,15,16]. Although the causal relationship is not clear, it has been shown that muscles and LBP are related. An effective treatment strategy for chronic LBP (CLBP) is exercise therapy[17]. However, the effect of exercise therapy for patients with CLBP and sarcopenia, which decreases musculoskeletal muscle mass, is unclear. We hypothesized that exercise therapy is effective for patients with CLBP and sarcopenia. This study aimed to investigate the outcomes of short-term exercise therapy for patients with CLBP with or without sarcopenia.

Materials and Methods

This was a prospective cohort study. The participants included patients with CLBP who were diagnosed to have no specific disease causing back pain (BP) by an orthopedic spine surgeon certified by the Japanese Orthopaedic Association and the Japanese Society for Spine Surgery and Related Research. They were admitted to our center and administered conservative therapy, mainly including exercise therapy. Our study protocol consisted of 2 weeks of short-term hospitalization, which included exercise therapy and pharmacotherapy. After discharge, the patients were instructed to continue the exercise, which was performed under supervision by a physical therapist during their hospital stay. Additionally, they were also checked for exercise positions and adherence to the exercise schedule once a week for 3 months at our center (Fig. 1). For pharmacotherapy, only nonsteroidal anti-inflammatory drugs (NSAIDs) were used as needed, but not epidural steroid injections, duloxetine, acetaminophen, and opioids.

Participants

Consecutive patients with CLBP aged >65 years who were hospitalized and treated from September 2017 to November 2018 were included in this study. At outpatient visits, these patients were confirmed not to have any specific diseases through radiography and magnetic resonance imaging. For inclusion criteria, LBP was defined as pain from the lowest rib to the gluteal fold and CLBP as pain that lasted for ≥12 weeks[17]. The inclusion criteria were CLBP, pain intensity > 3 on the numerical rating scale (NRS), nonreceipt of exercise therapy at any other hospital or clinic, and inability to work due to BP. The exclusion criteria were acute LBP, lower extremity osteoarthritis that required treatment, having undergone surgical treatment, neurological complications, dementia, having extended leave due to a disease, or getting insurance as a result of an accident. This study has been approved by the Institutional Review Board of our affiliated institution. All patients provided their written informed consent prior to participation, and those who met the inclusion criteria and provided consent were consecutively enrolled in this study.

Intervention

All patients underwent an exercise program supervised by a physical therapist. The program included trunk muscle training, especially the transversus abdominis and multifidus muscles; stretching; stationary cycling; and other exercise therapies tailored to individual conditions, such as lower limb muscle strength training, joint mobilization, and guidance of posture and movement that does not overbend and add stress on the lumbar area. Aerobic exercise was performed for >15 min with appropriate loads. The patients underwent two sessions of exercise therapy daily (each session lasting 40-60 min), five to six times a week during 2 weeks of hospitalization. After discharge, they were instructed to continue the exercise that they performed during their hospitalization. Pain control was individualized using NSAIDs.

Outcome assessments

Demographic characteristics, including age, sex, body height, body weight, body mass index (BMI), skeletal muscle index (SMI), and LBP duration, were recorded. The primary outcome measure was BP intensity measured using the NRS and Vestibular Disorders Activities of Daily Living Scale score for LBP measured using the Roland-Morris Disability Questionnaire (RMDQ). The NRS scores range from 0 (no pain) to 10 (worst pain imaginable). The RMDQ measures patient-reported outcomes and consists of 24 items, which evaluate the degree to which daily life is impaired by BP. The score ranges from 0 (no disability) to 24 (maximum disability), depending on the questionnaire. The NRS and RMDQ determine the clinical efficacy of an intervention using minimal clinically important difference (MCID). Jaeschke et al. defined MCID as the "smallest difference in score in the domain of interest, which patients perceive as beneficial and which would mandate, in the absence of troublesome side effects and excessive cost, a change in the patient's management"[18]. Previously, a reduction of 2 points in the NRS score[19] and 30% in the RMDQ score[20] represented the MCID for patients.

The secondary outcomes were the results of the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ), the Hospital Anxiety and Depression Scale (HADS), the trunk muscle strength test, the 5-level version of the EuroQol 5-dimension (EQ-5D-5L) instrument[21], and the NRS of treatment satisfaction. The JOABPEQ is a multifactorial evaluation questionnaire and consists of five domains: pain-related disorder, lumbar spine dysfunction, gait disturbance, social life dysfunction, and psychological disorder[22]. The range of the score for each of its subscales is from 0 to 100, with higher scores indicating better condition, and if the score increases by ≥20 points or improves from <90 points to ≥90 points, the treatment is judged as ef-

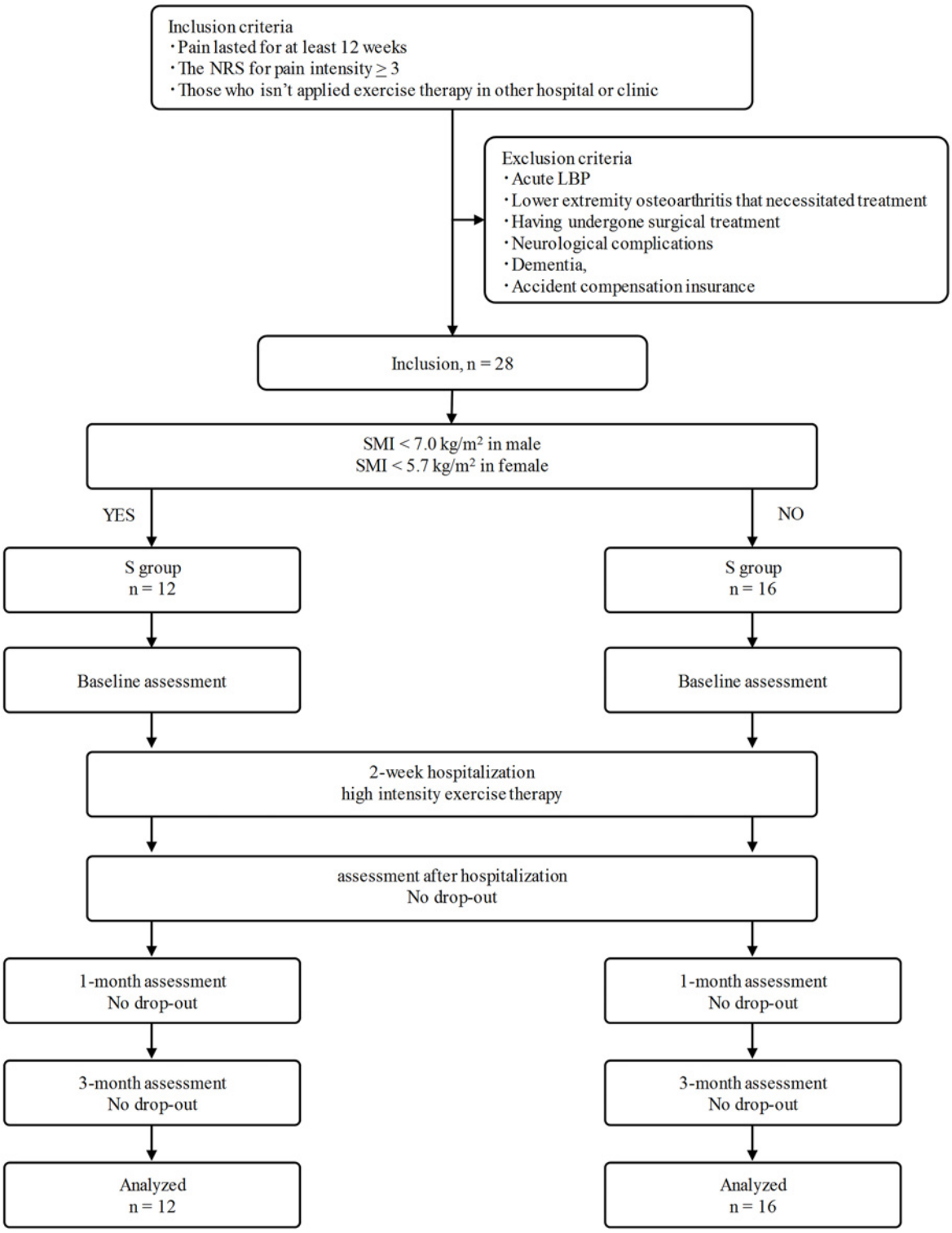

Figure 1. Flow diagram. NRS: Numerical rating scale; LBP: Low back pain; SMI: Skeletal muscle index; S group: Sarcopenia group; NS group: Nonsarcopenia group

fective. Additionally, an increase of 20 points in each domain of the JOABPEQ represented an MCID for the patient[23]. The SMI was measured by bioelectrical impedance analysis using a body composition meter (InBody S10; InBody, Tokyo, Japan). Patients were evaluated after 10 min in the supine position. Isokinetic trunk muscle strength (i.e., trunk flexor and spinal extensor) was measured using Biodex System 4 (Biodex Medical Systems, Shirley, NY, USA) at an angular velocity of 60°. For standardization, the obtained torque (Nm) was calculated as a percentage by dividing by the body weight (kg). The satisfaction of treatment was evaluated using NRS scores from 0 (unsatisfied) to 10 (very satisfied). Each datum was measured at baseline, 2 weeks after admission (at discharge), and at 1- and 3-month follow-ups. All patients responded to all the questionnaires alone in a quiet room. The assessors were blinded to

Table 1. Demographic and Baseline Characteristics of Participants with Chronic Low Back Pain.

	All	NS group	S group	P value
No. of patients	28	16	12	
Age, years	70.7 (9.8)	67.7 (9.1)	74.7 (9.7)	0.06[a)]
%Female, %	71.4	62.5	83.3	0.23[b)]
Body height, cm	155.2 (9.8)	159.0 (9.8)	150.1 (7.6)	<0.05[a)]
Body weight, kg	55.0 (12.4)	60.9 (13.2)	47.2 (4.8)	<0.01[a)]
BMI, kg/m^2	22.7 (3.5)	23.9 (3.9)	21.0 (2.0)	<0.05[a)]
SMI, kg/m^2	6.4 (1.1)	7.0 (1.1)	5.6 (0.5)	<0.001[a)]
Pain duration, month	117.9 (125.2)	129.8 (126.0)	101.9 (127.9)	0.57[a)]
Prevalence of a sarcopenia, %	42.9			

Abbreviation: NS, non-sarcopenia; S, sarcopenia; BMI, body mass index; SMI, skeletal muscle index
Value are means (standard deviation), a) non-paired t-test, b) Fisher's exact test

the patient groups. We also minimized bias by having a blinded and independent physical therapist perform all the baseline examinations and follow-up reexaminations.

Statistical analysis

All analyses were conducted using the JMP software (v. 14; SAS Institute, Cary, NC, USA). Participants with sarcopenia were identified using the definition of Asian Working Group for Sarcopenia[24)], in which the SMI < 7.0 kg/m^2 in men and <5.7 kg/m^2 in women. All patients were divided into sarcopenia (S) and nonsarcopenia (NS) groups. To estimate the group differences in response to treatment at both time points, a liner mixed model analysis was conducted with an unstructured covariance. The model included treatment, time, and treatment × time interaction as fixed effects. We compared patient characteristics using the nonpaired *t*-test and the JOABPEQ results using the Mann-Whitney *U* test in between groups. For the EQ-5D-5L, the ratio of the number of patients who exhibited a changed score that exceeded the MCID[25)] (0.03) of all patients within the group was compared between the two groups using Fisher's exact test. The nominal scale was analyzed using the chi-squared test, but it did not require age and sex to be included in the final models. The missing data were processed using the last-observation-carried-forward method. Two-sided P < 0.05 was considered statistically significant.

Results

Twenty-eight patients were included in this prospective study. The mean patient age was 70.7 ± 9.8 years, body height 155.2 ± 9.8 cm, body weight 55.0 ± 12.4 kg, BMI 22.7 ± 3.5 kg/m^2, SMI 6.4 ± 1.1 kg/m^2, and pain duration 117.9 ± 125.2 months; 71.4% of the patients were women. The patients' baseline characteristics are presented in Table 1. All patients were divided into two groups based on the SMI: S (n = 12) and NS (n = 16) groups. The prevalence rate of sarcopenia was 42.9%. Body height (150.1 ± 7.6 cm vs 159.0 ± 9.8 cm; P < 0.05), body weight (47.2 ± 4.8 kg vs 60.9 ± 13.2 kg; P < 0.01), BMI (21.0 ± 2.0 kg/m^2 vs 23.9 ± 3.9 kg/m^2, P < 0.05), and SMI (5.6 ± 0.5 kg/m^2 vs 7.0 ± 1.1 kg/m^2, P < 0.001) in the S group were significantly lower than those in the NS group, but age (74.7 ± 9.7 years vs 67.7 ± 9.1 years, P = 0.06), proportion of women (83.3% vs 62.5%, P = 0.23), and pain duration (117.9 ± 125.2 months vs 129.8 ± 126.0 months, P = 0.57) were not significantly different. At baseline, there were no significant differences in the JOABPEQ domains (pain-related disorder: 58.3 ± 39.7 vs 39.2 ± 30.2, P = 0.19; lumbar spine dysfunction: 76.4 ± 15.4 vs 59.4 ± 29.3, P = 0.18; gait disturbance: 44.6 ± 21.8 vs 37.5 ± 24.4, P = 0.44; social life dysfunction: 46.4 ± 15.1 vs 42.4 ± 13.0, P = 0.17; and psychological disorder: 48.1 ± 16.2 vs 43.6 ± 13.8, P = 0.38). In the NRS for BP, there was no significant difference between the two groups upon follow-up, but both groups exhibited an improvement greater than the MCID at discharge and maintained this improvement until the 3-month follow-up (Table 2). Similarly, in the RMDQ results, there was no significant difference between the groups at baseline, but both groups exhibited an improvement greater than the MCID at discharge and follow-up. Only the NS group exhibited a statistically significant improvement from baseline to the 3-month follow-up (Table 2). Regarding the JOABPEQ subscales, psychological disorder and lumbar spine dysfunction exhibited lower scores in the S group than in the NS group at the 3-month follow-up (14.1 ± 3.9 in the NS group, 3.3 ± 4.5 in the S group, P < 0.1), and pain-related disorder and gait disturbance exhibited scores over 20 points higher (Fig. 2). There was no statistically significant difference in the other subscales, e.g., most of the subscales tended to exhibit lower scores in the S group than in the NS group (Table 2). As for the HADS, both anxiety and depression were improved at discharge in the NS group, whereas in the S group, there was no significant improvement. The trunk flexor strength of the NS group was statistically increased at the 1- and 3-month follow-ups, whereas in the S group, the trunk flexor and extensor strengths were increased at each time point, but were not statistically different. Additionally, there were no differences in the trunk flexor and extensor strengths at each time point between the groups. For the EQ-5D-5L, the ratio of the number of patients who exhibited a changed score that exceeded 0.03 in the S group was lower than that

Table 2. Primary and Secondary Outcomes.

	NS group		S group		Group Difference, Least Squares Means (95% CI)	Mean Effect of Time		Interaction Effect	
	Least Squares Means (SE)	Within Group Difference, Least Squares Means (95% CI)	Least Squares Means (SE)	Within Group Difference, Least Squares Means (95% CI)		F Score	P	F Score	P
Primary outcome measure									
NRS score (of 10)									
Baseline	5.125 (0.448)	NA	5.917 (0.518)	NA	-0.792 (-2.924 to 1.341)	29.018	<.0001	0.547	.65
2-week	2.281 (0.448)	-2.844 (-4.429 to -1.259)	2.208 (0.518)	-3.708 (-5.539 to -1.878)	0.073 (-2.060 to 2.206)				
1-month	2.594 (0.448)	-2.531 (-4.117 to -0.946)	2.542 (0.518)	-3.375 (-5.206 to -1.545)	0.052 (-2.081 to 2.184)				
3-month	3.000 (0.448)	-2.125 (-3.710 to -0.540)	3.333 (0.518)	-2.583 (-4.414 to -0.753)	-0.333 (-2.466 to 1.800)				
RMDQ score									
Baseline	10.750 (1.176)	NA	8.500 (1.358)	NA	2.250 (-3.347 to 7.847)	14.242	<.0001	0.851	.47
2-week	6.250 (1.176)	-4.500 (-7.326 to -1.674)	5.750 (1.358)	-2.750 (-6.013 to 0.513)	0.500 (-5.097 to 6.097)				
1-month	6.875 (1.176)	-3.875 (-6.701 to -1.049)	4.333 (1.358)	-4.167 (-7.430 to -0.903)	2.542 (-3.055 to 8.138)				
3-month	7.125 (1.176)	-3.625 (-6.451 to -0.799)	5.500 (1.358)	-3.000 (-6.263 to 0.263)	1.625 (-3.972 to 7.222)				
Secondary outcome measure									
HADS Anxiety									
Baseline	5.313 (0.832)	NA	5.500 (0.961)	NA	-0.188 (-4.138 to 3.772)	4.314	.0072	1.762	.16
2-week	2.625 (0.832)	-2.688 (-4.488 to -0.491)	4.750 (0.961)	-0.750 (-3.287 to 1.787)	-2.125 (-6.085 to 1.835)				
1-month	3.563 (0.832)	-1.750 (-3.947 to 0.447)	4.000 (0.961)	-1.500 (-4.037 to 1.037)	-0.438 (-4.397 to 3.522)				
3-month	3.188 (0.832)	-2.123 (-4.322 to 0.007)	5.167 (0.961)	-0.333 (-2.870 to 2.203)	-1.979 (-5.939 to 1.980)				
HADS Depression									
Baseline	5.688 (0.791)	NA	6.417 (0.914)	NA	-0.729 (-4.495 to 3.036)	7.964	.0001	0.964	.41
2-week	3.000 (0.791)	-2.688 (-4.556 to -0.819)	5.000 (0.914)	-1.417 (-3.574 to 0.741)	-2.000 (-5.765 to 1.765)				
1-month	4.000 (0.791)	-1.688 (-3.556 to 0.181)	4.583 (0.914)	-1.833 (-3.991 to 0.324)	-0.583 (-4.349 to 3.182)				
3-month	4.000 (0.791)	-1.688 (-3.556 to 0.181)	5.083 (0.914)	-1.333 (-3.491 to 0.824)	-1.083 (-4.849 to 2.682)				
Trunk extensor strength, Nm/kg×10^2									
Baseline	132.166 (19.373)	NA	112.093 (22.491)	NA	20.072 (-71.795 to 111.939)	3.210	.03	0.295	.83
2-week	181.678 (19.373)	49.513 (-34.861 to 133.886)	145.260 (22.491)	33.167 (-64.260 to 130.593)	36.418 (-55.449 to 128.285)				
1-month	196.159 (19.373)	63.994 (-20.380 to 148.367)	150.860 (22.491)	38.767 (-58.660 to 136.193)	45.299 (-46.568 to 137.166)				
3-month	210.478 (19.373)	78.313 (-6.061 to 162.686)	152.360 (22.491)	40.267 (-57.160 to 137.693)	58.118 (-33.749 to 149.985)				

Table 2. continued.

	NS group		S group		Group Difference, Least Squares Means (95% CI)	Mean Effect of Time		Interaction Effect	
	Least Squares Means (SE)	Within Group Difference, Least Squares Means (95% CI)	Least Squares Means (SE)	Within Group Difference, Least Squares Means (95% CI)		F Score	P	F Score	P
Trunk flexor strength, Nm/kg×10^2									
Baseline	88.150 (9.924)	NA	85.942 (11.459)	NA	2.208 (-45.009 to 49.426)	8.138	<.0001	0.731	.54
2-week	106.056 (9.924)	17.906 (-3.923 to 39.736)	95.358 (11.459)	9.417 (-15.790 to 34.623)	10.698 (-36.519 to 57.915)				
1-month	113.431 (9.924)	25.281 (3.452 to 47.111)	104.942 (11.459)	8.093 (-6.206 to 44.206)	8.490 (-38.728 to 55.707)				
3-month	119.481 (9.924)	31.331 (9.502 to 53.161)	101.592 (11.459)	15.650 (-9.556 to 40.856)	17.890 (-29.328 to 65.107)				
EQ-5D-5L									
Baseline	0.671 (0.026)	NA	0.650 (0.030)	NA	0.021 (-0.102 to 0.144)	0.844	.474	0.730	.54
2-week	0.735 (0.026)	0.064 (-0.027 to 0.155)	0.653 (0.030)	0.004 (-0.101 to 0.109)	0.082 (-0.042 to 0.205)				
1-month	0.700 (0.026)	0.030 (-0.061 to 0.121)	0.664 (0.030)	0.014 (-0.091 to 0.119)	0.037 (-0.087 to 0.160)				
3-month	0.701 (0.026)	0.031 (-0.061 to 0.122)	0.671 (0.030)	0.021 (-0.084 to 0.127)	0.030 (-0.093 to 0.153)				
Satisfaction of treatment									
2-week	9.000 (0.3448)	NA	8.833 (0.3981)	NA	0.1667 (-1.391 to 1.725)	4.046	.023	1.951	.15
1-month	8.875 (0.3448)	-0.125 (-1.240 to 0.990)	7.758 (0.3981)	-1.25 (-2.538 to 0.038)	1.292 (-0.266 to 2.850)				
3-month	8.625 (0.3448)	-0.375 (-1.490 to 0.740)	7.750 (0.3981)	-1.083 (-2.371 to 0.204)	0.875 (-0.683 to 2.433)				

Abbreviation: NS, non-sarcopenia; S, sarcopenia; SE, standard error; NRS, Numerical Rating Scale; RMDQ, Roland-Morris Disability Questionnaire; HADS, Hospital Anxiety and Depression scale; NM, Newton meter; EQ-5D-5L, a EuroQol 5-dimension 5-level; NA, not applicable.
*ALL analyses were conducted using a linear mixed model.

in the NS group. However, there was no significant difference between the groups in the proportion of patients exhibiting an improvement in the EQ-5D-5L results over the MCID (62.5% vs 41.7% at 2 weeks, P = 0.45; 56.3% vs 41.7% at 1 month, P = 0.70; 50.0% vs 41.7% at 3 months, P = 0.72) (Table 3). There was no statistically significant difference within or between groups in the EQ-5D-5L; however, the QoL score of the S group was lower by 0.03 than that of the NS group for all follow-up periods, and it was increased by 0.03 from baseline over all follow-up periods in the NS group. The treatment satisfaction in the S group tended to be lower than in the NS group over the follow-up period.

Discussion

This study investigated whether sarcopenia influences the therapeutic effect of 2 weeks of hospitalization and high-intensity exercise therapy for elderly patients with CLBP. This short-term high-intensity exercise therapy improved BP and disability, including gait disturbance, in patients with or without sarcopenia. Therefore, exercise therapy was effective for elderly patients with CLBP. Additionally, the treatment satisfaction was high, and there were no patient dropouts; thus, the follow-up ratio in this study was 100%.

The prevalence rate of sarcopenia was 42.9% in our study. Previous studies reported the prevalence rate of sarcopenia as 16%-24% for lumbar spinal stenosis[26], 46.6% for lumbar degenerative scoliosis[27], 43.3% for cervical myelopathy[28], and 25%-35.5% for LBP[29,30]. Our study had a higher prevalence of sarcopenia than reported previously.

Our results are in line with a previous report on the effect of exercise for patients with sarcopenia[31]. Exercise therapy can contribute to the improvement of LBP and disability by maintaining activity and enhancing physical function despite the presence of sarcopenia. Therefore, regarding the therapeutic effects of our study, exercise therapy was shown to be effective because BP and disability were improved regardless of sarcopenia. The QoL of the NS group increased by 0.03 points from baseline to the follow-up periods, which was not significantly different. The QoL of the S group did not exhibit a significant chronological change, which was lower than that of the NS group by ≥0.03. The MCID in the EQ-5D-5L was reported as 0.03[25]; thus, patients with CLBP

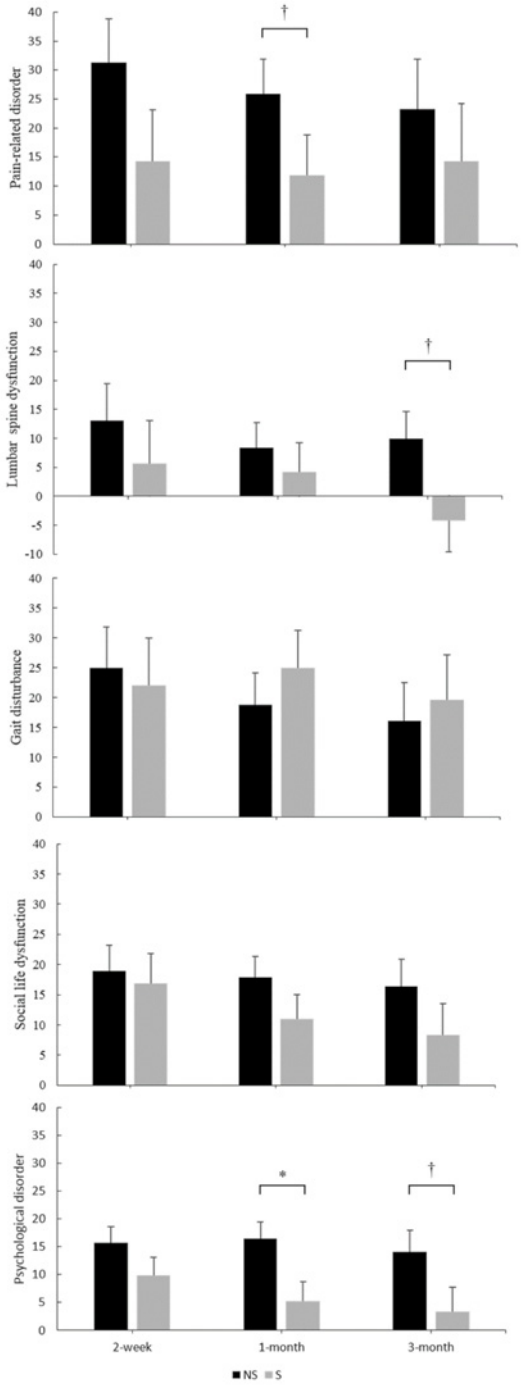

Figure 2. The obtained scores of the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ) subscales from baseline to follow-up. The JOABPEQ consists of five domains: pain-related disorder (a), lumbar spine dysfunction (b), gait disturbance (c), social life dysfunction (d), and psychological disorder (e). A significant difference in psychological disorder was found between the two groups at the 1-month follow-up. Psychological disorder and lumbar spine dysfunction exhibited lower scores in the S group than in the NS group at the 3-month follow-up, and pain-related dysfunction and gait disturbance exhibited scores over 20 points higher. † indicates P<0.1. * indicates P<0.05. Data are expressed as mean±standard error.

Table 3. The Proportion of Patients with Improved EQ-5D-5L over Minimal Clinical Important Difference.

	NS group	S group	P
2-week	62.5%	41.7%	.45[a)]
1-month	56.3%	41.7%	.70[a)]
3-month	50.0%	41.7%	.72[a)]

Abbreviation: NS, non-sarcopenia; S, sarcopenia; EQ-5D-5L, a EuroQol 5-dimension 5-level
a) Fisher's exact test

and sarcopenia had clinically lower QoL. We wondered if patients in the S group might have had a low perceived recovery. Sarcopenia is associated with anxiety, depression, and worse QoL[32,33]. LBP has also been reported to affect anxiety and depression[34,35]. Therefore, sarcopenia and LBP might have additive or synergistic effects on mental status and QoL.

Regarding the association between depression and sarcopenia, brain-derived neurotrophic factor (BDNF) has recently been recognized as a factor related to skeletal muscle and depression. BDNF levels of patients with depression, lower physical function, lower BMI, or small skeletal muscle mass were significantly lower than healthy individuals[36-38]. Mackey et al. reported the effects of aerobic exercise on BDNF levels using a systematic review and meta-analysis and demonstrated that aerobic exercise can increase BDNF levels when compared with usual care or nil therapy[39]. However, the exercise intensity or dose must be considered because a variation in these parameters can alter the effect on BDNF levels[40]. Therefore, patients with CLBP with sarcopenia may need aerobic exercises as well as resistance training, to improve not only their LBP and disability but also their QoL and treatment satisfaction.

This study has some limitations. Although statistical power was obtained within the groups, the number of patients in each group was small. There was no control group. Presarcopenia was diagnosed as sarcopenia by only using SMI without evaluating physical function. Most of the patients were elderly, and compliance with exercise after discharge was not assessed. The long-term effects are not clear, and the serum BDNF level was not measured in the present study. In addition, the effects of patients who discontinued our strategy were unclear. Recently, the association between sagittal balance and QoL has been emphasized[41,42], but radiographic sagittal alignment was not measured in the present study. Therefore, long-term follow-up, measurement of BDNF, evaluations of sagittal alignment parameters, and effects of exercise adherence are needed as further studies.

Our study has revealed that short-term exercise therapy for elderly patients with CLBP with or without sarcopenia improved BP intensity, disability, and gait disturbance, which resulted in high treatment satisfaction. Sarcopenia has a high prevalence in elderly patients with CLBP. Moreover, even if their pain and disability are improved, their QoL and

treatment satisfaction may be lower than those of patients without sarcopenia. To improve these parameters, it will be necessary to examine an aerobic exercise program that is adjusted for exercise intensity and dose.

Disclaimer: Mamoru Kawakami is one of the Editors of Spine Surgery and Related Research and on the journal's Editorial Committee. He was not involved in the editorial evaluation or decision to accept this article for publication at all.

Conflicts of Interest: The authors declare that there are no relevant conflicts of interest.

Author Contributions: MN drafted the manuscript. MN and MM performed the statistical analysis. MN, MK, and MM contributed to the analysis and interpretation of the results. All authors have read, reviewed, and approved the manuscript.

Informed Consent: Informed consent was obtained from all participants in this study.

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