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Original article

The impact of sarcopenia on the results of lumbar spinal surgery

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ABSTRACT

Objectives: As the population ages, the number of lumbar spinal surgeries performed on sarcopenic patients will increase. The purpose of this study was to investigate the prevalence of sarcopenia and evaluated its impact on the results of lumbar spinal surgery.

Methods: This study included 2 groups: One group consisted of patients who underwent whole-body dual-energy X-ray absorptiometry (DXA) scanning before the option of undergoing surgery for lumbar spinal disease (LSD group) and a second group consisted of patients underwent DXA scanning for osteoporosis screening under hospital watch at the geriatric medicine department (control group). In order to evaluate the impact of sarcopenia on the clinical outcome of lumbar spinal surgery, the Japanese Orthopedic Association (JOA) score, the recovery rate based on the JOA score, and visual analogue scale (VAS) scores for lower back pain, lower extremity pain, and lower extremity numbness were compared within the LSD group.

Results: The prevalence of sarcopenia showed no statistical difference between groups (control group, 50.7%; LSD group, 46.5%). In the LSD group, while the changes in VAS scores showed no statistical difference between the nonsarcopenia subgroup and sarcopenia subgroup, the sarcopenia subgroup demonstrated inferior JOA scores and recovery rates at the final follow-up when compared with the nonsarcopenia subgroup ($P < 0.05$).

Conclusions: This study demonstrated a high prevalence of sarcopenia among the elderly populations in Japan and a negative impact of sarcopenia on clinical outcomes after lumbar spinal surgery.

1. Introduction

In Japan, people over 65 years old already account for more than a quarter of the total population, and the proportion of aging people in the total population is increasing rapidly. Frailty is a common clinical syndrome in older adults that carries an increased risk for poor health outcomes [1] and is also an independent predictor of postoperative complications, mortality, and reoperation in patients undergoing surgery for adult spinal deformity [2]. Recently, frailty screening of preoperative patients significantly improved surgical outcomes in major surgery [3]. A major component of frailty is sarcopenia, a progressive geriatric syndrome, which was first defined in 1989 by Rosenberg as loss of muscle mass, strength, and function related to ageing [4].

Lumbar spinal diseases such as lumbar canal stenosis cause lower back pain, lower extremity pain, lower extremity numbness, lower muscle weakness, and gait disturbance, resulting in decreased physical function. Moreover, degenerative lumbar spinal diseases cause paraspinal/lower extremity muscular atrophy and fatty change due to muscle denervation and/or disuse [5]. Thus, it appears that lumbar spinal disorders might have a potent influence on the development of sarcopenia. As the Japanese population ages, the number of lumbar spinal surgeries performed on sarcopenic patients will likely increase. However, the precise prevalence of sarcopenia in patients with lumbar spinal disease has not been fully investigated. Presently, since spine surgeons do not yet fully understand the relationship between sarcopenia and lumbar spinal diseases, the effectiveness of spinal surgery on patients with sarcopenia in unknown. Our hypothesis is that patients with lumbar spinal disease have a higher rate of sarcopenia and the effectiveness of spinal surgery in patients with sarcopenia is lower than in

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patients without. The purpose of this study was to investigate the prevalence of sarcopenia in those with lumbar spinal disease and to evaluate the impact of sarcopenia on the results of lumbar spinal surgery.

2. Methods

Our institutional research ethics committee approved this study (approval number: M2016-299) and informed consent was waived since it was a retrospective, anonymized study. We performed a retrospective chart review to identify all patients over 65 years old who underwent whole-body dual-energy X-ray absorptiometry (DXA) (GE Healthcare, Buckinghamshire, UK) at our institution from January 1, 2014 through December 31, 2015.

This study included 2 groups. One group consisted of patients with lumbar spinal disease who underwent DXA scanning for the evaluation of skeletal muscle mass before the option of undergoing surgery (LSD group). The second group consisted of patients underwent DXA scanning for osteoporosis screening at the same period under regular hospital watch at the geriatric medicine department (control group) (Table 1).

The exclusion criteria for both groups included: previous spinal instrumentation surgery with pedicle screws, previous joint surgery with prosthesis, and concurrent serious medical conditions, such as sepsis and terminal malignancy or missing data.

Then, the impact of sarcopenia on spinal surgery results was evaluated within the LSD group. The overall LSD group consisted of patients with lumbar spinal disease who underwent preoperative DXA, the subgroup evaluated were patients that followed through with lumbar spinal surgery.

As for surgery, we performed conventional wide fenestration for lumbar canal stenosis without instability, posterior interbody fusion for lumbar canal stenosis with instability, vertebral column resection for sagittal deformity cases by lumbar compression fracture, and pedicle subtraction osteotomies for lumbar degenerative kyphosis.

Postoperatively, patients with lumbar canal stenosis and lumbar compression fracture received a soft brace for 3 months, patients with lumbar degenerative kyphosis received a hard brace for 6 months. The necessity for postoperative rehabilitation is evaluated based on their postoperative status, such as muscle weakness of lower limbs and/or disabilities in activities of daily living, such as standing, walking, and stair climbing. Rehabilitation methods included leg muscle functional strengthening and endurance, walking exercise, and advice on how to function in daily life.

2.1. Appendicular skeletal muscle mass index

Whole body DXA scans provided total lean body mass, total fat mass, and total body bone mineral content. Appendicular skeletal muscle mass (ASM) was determined by combining the lean tissue mass of arms and legs. ASM index was defined as ASM/height^2 (kg/m^2) [6].

2.2. Definition of sarcopenia

Sarcopenia was diagnosed when the ASM index by DXA was $\leq$7.0 kg/m^2 for male patients and $\leq$5.4 kg/m^2 for female patients, according to the recommended definition of sarcopenia proposed by the Asian Working Group for Sarcopenia [7].

2.3. Clinical outcomes

Clinical outcome was assessed by means of the scoring system proposed by the Japanese Orthopedic Association (JOA). The recovery rate based on the JOA score was calculated according to the following formula: recovery rate = [(postoperative score − preoperative score)/(29 − preoperative score)] × 100% [8]. In addition, a visual analogue scale (VAS) score was used to evaluate the degree of lower back pain, lower extremity pain, and lower extremity numbness.

2.4. Matching technique

The matching technique applied in this study was based on the variables age and sex. One control per LSD case was randomly selected and matched for age and sex from the control population.

2.5. Statistical analysis

We used Fisher exact test with regard to gender, type of lumbar spinal disease, and surgical procedure. The Mann-Whitney *U* test was used to analyze other data. JMP ver. 12 (SAS Institute, Cary, NC, USA) was used for statistical analysis, and p-values less than 0.05 were considered statistically significant.

3. Results

A total of 243 patients were enrolled in this study. The mean age was 78.0 years in the control group and 73.8 years in the LSD group. While 93 (61.2%) were diagnosed with sarcopenia in the control group, 39 (42.9%) were diagnosed with sarcopenia in the LSD group (Table 1). Thus, the prevalence of sarcopenia was higher in the control group ($P < 0.01$); however, the mean age was also higher in the control group ($P = 0.01$). To investigate the influence of lumbar spinal disease on the development of sarcopenia, controlling for age and sex, matching was performed on control and LSD groups. As a result, 71 matched pairs without residual significant differences were created. While 36 (50.7%) were diagnosed with sarcopenia in the matched control group, 33 (46.5%) were diagnosed with sarcopenia in the matched LSD group (Table 2). Thus, there was no difference in the prevalence of sarcopenia in lumbar spinal disease versus geriatric medicine patients.

Next, the impact of sarcopenia on spinal surgery results was evaluated within the LSD group. The overall LSD group consisted of

Table 1
Demographic data of 243 patients.

Characteristic	Control (n = 152)	LSD (n = 91)	P-value
Age, yr	78.0 ± 0.6	73.8 ± 0.7	<0.01*
Sex			0.09
Male	76	35	
Femlae	76	56	
Sarcopenia	93	39	0.01*

Values are presented as mean ± standard deviation or number.
LSD, Lumbar spinal disease.
*P < 0.05, statistically significant differences.

Table 2
Demographic data of matched patients.

Characteristic	Matched control (n = 71)	Matched LSD (n = 71)	P-value
Age, yr	74.6 ± 0.7	74.9 ± 0.6	0.71
Sex			0.73
Male	29	26	
Femlae	42	45	
Sarcopenia	36	33	0.74

Values are presented as mean ± standard deviation or number.
LSD, Lumbar spinal disease.

91 patients who underwent preoperative DXA, the subgroup evaluated were the 85 patients that followed through with surgery. Lumbar spinal diseases consisted of lumbar canal stenosis (78 cases), lumbar compression fracture (3 cases), and lumbar degenerative kyphosis (4 cases) (Table 3). While sarcopenia subgroup had a trend toward decreased total body T score and higher VAS scores for lower back and lower extremity pain, there were no statistically significant differences between nonsarcopenia and sarcopenia subgroups for baseline differences (Table 3). In terms of surgical outcome, while preoperative L-JOA scores did not differ significantly, L-JOA scores (24.7 ± 0.4 vs. 23.0 ± 0.6, P = 0.01) and recovery rates (68.6 ± 3.3 vs. 53.8 ± 5.2, P = 0.04) at the final follow-up were significantly lower in the sarcopenia subgroup (Table 4). While the mean VAS scores for lower back pain, lower extremity pain, and lower extremity numbness before surgery were significantly decreased at final follow-up within subgroups, no statistical difference was found between the sarcopenia and nonsarcopenia subgroups (Table 4). Interestingly, the percentage of patients needed postoperative rehabilitation was high in the sarcopenia subgroup (P = 0.02) (Table 4).

Table 4
Results of neurological analysis.

Variable	Nonsarcopenia	Sarcopenia	P-value
JOA score at final follow-up	24.7 ± 0.4	23.0 ± 0.6	0.01*
Recovery rate at final follow-up, %	68.6 ± 3.3	53.8 ± 5.2	0.04*
VAS score change			
Lower back pain	32.5 ± 4.9	31.8 ± 6.0	0.74
Lower extremity pain	37.5 ± 5.4	37.1 ± 6.3	0.97
Lower extremity numbness	41.9 ± 4.8	32.5 ± 6.9	0.40
Patients that undergo rehabilitation, %	35.4	62.2	0.02*

Values are presented as mean ± standard deviation.
JOA, Japanese Orthopedic Association; VAS, visual analogue scale.
*P < 0.05, statistically significant differences.

4. Discussion

Patient-specific factors, such as coexistent medical illness [9] and duration of symptoms [10], are considered risk factors for poor surgical results in lumbar spinal surgery. The role of age in lumbar spinal surgical results remains highly debated. While some believe that age has a negative influence on the success of lumbar spinal surgery [11], others say that age plays no significant role in the success of lumbar spinal surgery [12]. In major surgery, sarcopenia has been reported to predict greater complication rates, discharge disposition, and in-hospital mortality [6]. Also in spinal surgery, elderly patients had increased risk of perioperative morbidity and mortality [11,13]. However, to the best of our knowledge, there are no studies that examined the clinical results of lumbar spinal surgery in terms of whether or not the patients were sarcopenic.

As for prevalence, sarcopenia occurs in up to 14.9% of community-dwelling Japanese populations in their seventies and 16.8% in their eighties based on DXA findings [14], and its prevalence is expected to rise as the population ages. Yamada et al. [15] reported that the prevalence of sarcopenia in community-dwelling Japanese men and women aged 65 to 89 was 21.8% and 22.1%, respectively. In Korea, the prevalence of sarcopenia in women >65 years was 22.1% using the same cutoff value of 5.4 kg/m^2 [16]. In this study, the prevalence of sarcopenia in the control group was much higher than previously reported; this difference might be attributed to the patient sample. Our sample came directly from geriatric medicine, not the general population. However, in consideration of quite a high prevalence of chronic diseases, such as hypertension and diabetes mellitus, which leads to constant visitation to facilities of geriatric medicine among the elderly population in the industrialized and developed nations of the world [17,18], it cannot be said that the control population involved in this study is not that of a typical sample. Moreover, current reports regarding the prevalence of sarcopenia in Japan have mainly come from suburban or countryside populations [19], with reports from urban populations remaining scarce. With our study, we have the opportunity to conduct our study on an urban population in the heart of Tokyo. As a result, we believe that the prevalence of sarcopenia might be more widespread in urban communities than previously expected.

A retrospective study demonstrated that the prevalence of sarcopenia, as defined by hand grip strength, in populations with degenerative spinal canal stenosis, was 24%, while it was 12% in control populations in Korea [20]. While a previous study of sarcopenia prevalence in lumbar spinal stenosis defined sarcopenia based on hand grip strength and skeletal muscle mass measured by bioelectric impedance (BIA) [20], DXA was applied in this study instead. Though the results of BIA have been shown to correlate with DXA, BIA results were confounded by fluid retention [21].

Table 3
Demographic data of lumbar spinal disease group.

Characteristic	Nonsarcopenia (n = 48)	Sarcopenia (n = 37)	P-value
Age, yr	73.0 ± 1.0	74.8 ± 0.9	0.31
Sex			0.27
Male	16	17	
Female	32	20	
Duration of symptoms, d	2004.4 ± 264.4	2003.5 ± 364.0	0.47
No. of each lumbar spinal disease, case			0.10
Lumbar canal stenosis	45	33	
Lumbar degenerative kyphosis	3	1	
Lumbar compression fracture	–	3	
Total body T score	−0.73 ± 0.20	−1.05 ± 0.23	0.12
Operative procedure			0.10
Fusion	38	23	
Nonfusion	10	14	
Preoperative L-JOA score	15.1 ± 0.4	14.8 ± 0.7	0.93
Preoperative VAS score			
Lower back pain	59.2 ± 3.6	64.9 ± 5.7	0.14
Lower extremity pain	67.5 ± 3.02	72.3 ± 4.8	0.13
Lower extremity numbness	70.8 ± 3.3	69.2 ± 5.1	0.65
Follow-up period, d	393.3 ± 31.1	407.1 ± 28.1	0.51

Values are presented as mean ± standard deviation or number.
L-JOA, Lumbar-Japanese Orthopedic Association, VAS, Visual analogue scale.

Thus, the diagnosis and prevalence of sarcopenia reported in this study may be more accurate.

We began with the hypothesis that LSD leads to the development of sarcopenia; however, our results indicate that this may not be the case. Moreover, the skeletal muscle mass one year postoperatively did not always show improvement even if the prior surgery was successful (unpublished observation). Although LSD may affect the rate at which skeletal muscle mass declines, our data indicates that the contribution of an individual's peak skeletal muscle mass is more important in the development of sarcopenia. Even if lumbar spinal surgery is successful, there should still be a long period to recover from a sarcopenic state. On the other hand, the sarcopenia subgroup demonstrated inferior JOA and recovery rate results at final follow-up when compared with the non-sarcopenia subgroup. This supported our hypothesis that the effectiveness of spinal surgery for patients with sarcopenia was lower than in patients without. The inferior results might be due to reduced skeletal muscle mass in patients with sarcopenia, making it more difficult to improve their activities of daily living. However, as shown by VAS score results, lumbar spinal surgery for sarcopenic patients was equally effective in nonsarcopenic patients in terms of pain relief.The proportion of patients who needed postoperative rehabilitation was higher in sarcopenia subgroup in our study. A randomized controlled trial showed that resistance exercise combined with protein supplementation was an effective strategy to improve strength and physical performance in frail elderly people [22]. It was also demonstrated that a combination of exercise and amino acid supplementation was effective in enhancing muscle strength in sarcopenic women [23], and combination of vitamin D and amino acid supplementation resulted in improvements in muscle mass and lower-extremity function among sarcopenic older adults [24]. Seen the positive outcome of combination of exercise and nutrition (vitamin D and amino acid supplementation) for sarcopenic patients, it might be beneficial for sarcopenic patients to begin these intervention prior to undergoing surgery. Further prospective study is necessary whether preoperative/postoperative intervention with a combination of exercise and nutrition improve lumbar surgical results or not.

We note some limitations of this study. First, the patients of this study had different diseases, such as lumbar spinal stenosis and lumbar spinal fracture, which fell under the scope of lumbar spinal diseases. Although the disease type may have affected surgical results, common symptoms such as lower back pain, lower extremity pain, and lower extremity numbness, would be expected to affect skeletal muscle mass loss, similarly. Thus, in this study, we included these diseases for analysis. Second, not all patients were treated with the same surgical procedure (fusion and nonfusion); however, surgical results between these procedures have been shown to have no statistical difference [25]. Thus, in this study, we included both procedures for analysis.

In summary, based upon our data, while we could not find the evidence that LSD affects the development of sarcopenia, the prevalence of the geriatric syndrome sarcopenia was more widespread in Japan than expected. Since sarcopenia had a negative impact on surgical results after lumbar spinal surgery, it may be possible to identify patients at risk of poor surgical outcomes by using DXA to measure of skeletal muscle mass prior to operating on lumbar spinal disease. Moreover, it also might be beneficial for sarcopenic patients to begin rehabilitation and nutritional interventions prior to undergoing surgery.

Conflicts of interest

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

References

[1] Xue QL. The frailty syndrome: definition and natural history. Clin Geriatr Med 2011;27:1–15.
[2] Leven DM, Lee NJ, Kothari P, Steinberger J, Guzman J, Skovrlj B, et al. Frailty index is a significant predictor of complications and mortality after surgery for adult spinal deformity. Spine (Phila Pa 1976) 2016;41:E1394–401.
[3] Hall DE, Arya S, Schmid KK, Carlson MA, Lavedan P, Bailey TL, et al. Association of a frailty screening initiative with postoperative survival at 30, 180, and 365 days. JAMA Surg 2017;152:233–40.
[4] Epidemiologic and methodologic problems in determining nutritional status of older persons. Proceedings of a conference. Albuquerque, New Mexico, October 19-21, 1988. Am J Clin Nutr 1989;50(5 Suppl):1121–235.
[5] Lee JC, Cha JG, Kim Y, Kim YI, Shin BJ. Quantitative analysis of back muscle degeneration in the patients with the degenerative lumbar flat back using a digital image analysis: comparison with the normal controls. Spine (Phila Pa 1976) 2008;33:318–25.
[6] Cruz-Jentoft AJ, Landi F, Schneider SM, Zúñiga C, Arai H, Boirie Y, et al. Prevalence of and interventions for sarcopenia in ageing adults: a systematic review. In: Age ageing, vol. 43. Report of the International Sarcopenia Initiative (EWGSOP and IWGS); 2014. p. 748–59.
[7] Chen LK, Liu LK, Woo J, Assantachai P, Auyeung TW, Bahyah KS, et al. Sarcopenia in Asia: consensus report of the Asian Working group for sarcopenia. J Am Med Dir Assoc 2014;15:95–101.
[8] Inose H, Yamada T, Mulati M, Hirai T, Ushio S, Yoshii T, et al. Bone turnover markers as a new predicting factor for nonunion after spinal fusion surgery. Spine (Phila Pa 1976) 2018;43:E29–34.
[9] Katz JN, Lipson SJ, Brick GW, Grobler LJ, Weinstein JN, Fossel AH, et al. Clinical correlates of patient satisfaction after laminectomy for degenerative lumbar spinal stenosis. Spine (Phila Pa 1976) 1995;20:1155–60.
[10] Johnsson KE, Willner S, Pettersson H. Analysis of operated cases with lumbar renal stenosis. Acta Orthop Scand 1981;52:427–33.
[11] Deyo RA, Cherkin DC, Loeser JD, Bigos SJ, Ciol MA. Morbidity and mortality in association with operations on the lumbar spine. The influence of age, diagnosis, and procedure. J Bone Joint Surg Am 1992;74:536–43.
[12] Hee HT, Wong HK. The long-term results of surgical treatment for spinal stenosis in the elderly. Singap Med J 2003;44:175–80.
[13] Imajo Y, Taguchi T, Neo M, Otani K, Ogata T, Ozawa H, et al. Complications of spinal surgery for elderly patients with lumbar spinal stenosis in a super-aging country: an analysis of 8033 patients. J Orthop Sci 2017;22:10–5.
[14] Miyakoshi N, Hongo M, Mizutani Y, Shimada Y. Prevalence of sarcopenia in Japanese women with osteopenia and osteoporosis. J Bone Miner Metab 2013;31:556–61.
[15] Yamada M, Nishiguchi S, Fukutani N, Tanigawa T, Yukutake T, Kayama H, et al. Prevalence of sarcopenia in community-dwelling Japanese older adults. J Am Med Dir Assoc 2013;14:911–5.
[16] Kwon HJ, Ha YC, Park HM. Prevalence of sarcopenia in the Korean woman based on the Korean National Health and Nutritional examination surveys. J Bone Metab 2016;23:23–6.
[17] Jacob L, Breuer J, Kostev K. Prevalence of chronic diseases among older patients in German general practices. Ger Med Sci 2016;14:Doc03.
[18] Nguyen QT, Anderson SR, Sanders L, Nguyen LD. Managing hypertension in the elderly: a common chronic disease with increasing age. Am Health Drug Benefits 2012;5:146–53.
[19] Tanimoto Y, Watanabe M, Sun W, Sugiura Y, Hayashida I, Kusabiraki T, et al. Sarcopenia and falls in community-dwelling elderly subjects in Japan: defining sarcopenia according to criteria of the European Working Group on sarcopenia in Older People. Arch Gerontol Geriatr 2014;59:295–9.
[20] Park S, Kim HJ, Ko BG, Chung JW, Kim SH, Park SH, et al. The prevalence and impact of sarcopenia on degenerative lumbar spinal stenosis. Bone Joint J 2016;98-B:1093–8.
[21] Lustgarten MS, Fielding RA. Assessment of analytical methods used to measure changes in body composition in the elderly and recommendations for their use in phase II clinical trials. J Nutr Health Aging 2011;15:368–75.
[22] Tieland M, Dirks ML, van der Zwaluw N, Verdijk LB, van de Rest O, de Groot LC, et al. Protein supplementation increases muscle mass gain during prolonged resistance-type exercise training in frail elderly people: a randomized, double-blind, placebo-controlled trial. J Am Med Dir Assoc 2012;13:713–9.
[23] Kim HK, Suzuki T, Saito K, Yoshida H, Kobayashi H, Kato H, et al. Effects of exercise and amino acid supplementation on body composition and physical function in community-dwelling elderly Japanese sarcopenic women: a randomized controlled trial. J Am Geriatr Soc 2012;60:16–23.
[24] Bauer JM, Verlaan S, Bautmans I, Brandt K, Donini LM, Maggio M, et al. Effects of a vitamin D and leucine-enriched whey protein nutritional supplement on measures of sarcopenia in older adults, the PROVIDE study: a randomized, double-blind, placebo-controlled trial. J Am Med Dir Assoc 2015;16:740–7.
[25] Försth P, Ólafsson G, Carlsson T, Frost A, Borgström F, Fritzell P, et al. A randomized, controlled trial of fusion surgery for lumbar spinal stenosis. N Engl J Med 2016;374:1413–23.