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Original Article

Inter-examiner reliability in identifying lumbar paraspinal muscle atrophy by lumbar paraspinal muscle atrophy index, a novel parameter

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Abstract. [Purpose] To evaluate the inter-examiner reliability of our novel parameter, the lumbar paraspinal muscle atrophy index, in identifying the lumbar paravertebral muscle atrophy. [Participants and Methods] The study group consisted of 225 adults, with a mean age of 64.7 (range, 21–89) years, who underwent posterior lumbar spinal surgery for degenerative spinal disease at our hospital between July 2013 and June 2017. Preoperative axial T2-weighted magnetic resonance images were used to evaluate the lumbar paraspinal muscle atrophy index and observe the presence or absence of severe lumbar paraspinal muscle atrophy. The lumbar paraspinal muscle atrophy index was calculated at each intervertebral level, from L1-2 through L4-5, once by two examiners, and the Cohen's kappa statistic was used to calculate the inter-examiner agreement of the classification of the presence or absence of atrophy at each level. [Results] The agreement was high (kappa, 0.79–0.88) for the lumbar paraspinal muscle atrophy index at all levels, except at the L3-4 level (kappa, 0.49). The lower kappa statistic at L3-4 likely reflects the unique morphological characteristics at this level. [Conclusion] The lumbar paraspinal muscle atrophy index is a new, simple, easy-to-use, and sufficiently reliable parameter to identify lumbar paraspinal atrophy.

Key words: Lumbar paraspinal muscle, Inter-rater reliability, Low-back pain

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INTRODUCTION

In Japan, the segment of the general population ≥65 years of age accounted for approximately 28.8% of the total population in 2020[1], with a high incidence of low back pain (LBP) associated with aging[2, 3]. At the lumbar spine, the erector spinae muscles play an important role in trunk stabilization[2–4]. Degenerative changes of the erector spinal muscles are known to be associated with lumbar spine pain, motor dysfunction, and spinal deformities[5–12]. Therefore, assessment of the degree of lumbar paraspinal muscle atrophy would be important in the treatment planning of patients with spinal disorders[13]. Previous studies have evaluated muscle atrophy of the lumbar erector spinae, multifidus, and psoas major muscles using the cross-sectional area (CSA) measured on axial computed tomography (CT) and magnetic resonance (MR) images[14, 15]. Calculation of the CSAs, however, requires the use of image analysis software[16], which is time consuming, making it difficult to use it in busy clinical settings. Using lumbar MR cross-sectional images, Takayama et al. reported a high correlation between the muscle CSA and the lumbar indentation value (LIV), where the LIV is defined as the minimum length of a line connecting the bilateral muscle bellies of the paraspinal muscles and the spinous process at the superior level of each intervertebral space[17]. The LIV is used as a visual measure to identify the presence or absence of muscle atrophy of the lumbar paraspinal muscles.

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In this study we propose the lumbar paraspinal muscle atrophy index (LPMAI), which we can use to identify the presence or absence of severe muscle atrophy more easily than the LIV. While the LIV evaluates the minimum length of the line connecting the bilateral fascicles and spinous processes of the lumbar paraspinal muscles, the LPMAI identifies the presence or absence of severe muscle atrophy based on the position of the spinous processes relative to the bilateral fascicles of the lumbar paraspinal muscles. Our aim in this study was to evaluate the inter-examiner reliability of the LPMAI to identify severe muscle atrophy among patients with lumbar degenerative disease.

PARTICIPANTS AND METHODS

Our study was approved by the Institutional Review Board of Saitama Medical Center, Saitama Medical University (No. 1969-II). Owing to the retrospective design of our study, the requirement for written consent was waived. Opt-out information was posted on the website of Saitama Medical Center, Saitama Medical University.

The study group comprised 225 adults (≥20 years) who had undergone posterior spinal surgery for degenerative disease (spinal stenosis and/or lumbar disc herniation) at our hospital, between July 2013 and June 2017.

The study group included 142 males and 83 females, with a mean age of 64.7 (range, 21–89) years. Patients without preoperative T2 weighted MR axial images were excluded. The exclusion criteria were patients aged <20 years and patients who had undergone lumbar revision surgery.

The LPMAI was measured on preoperative T2 weighted MR axial images at the mid-level of the intervertebral disc space from intervertebral levels L1-2 through L4-5. The mid-level was calculated by displaying the sagittal plane images side-by-side. The LPMAI is positive if the spinous process is located posteriorly to the line connecting the bilateral muscle bellies (presence of muscle atrophy) and negative if the spinous process (absence of muscle atrophy) is located anteriorly to this line. The LPMAI was calculated once at each intervertebral space by two examiners (examiners A and B), with each examiner determining the presence (1) or absence (0) of muscle atrophy at each level (Fig. 1).

The inter-examiner agreement of the classification of the presence or absence of muscle atrophy at each intervertebral level was evaluated using Cohen's Kappa coefficient (k). Agreement was classified as described by Landis et al.[18] as follows: fair agreement (k-value, 0.21–0.40), moderate agreement (k-value, 0.41–0.60), substantial agreement (k-value, 0.61–0.80), and almost perfect or perfect agreement (k-value, 0.81–1.0). The level of significance was set at 5%. All analyses were performed using SPSS version 26 (IBM Corp. Released 2019. IBM SPSS Statistics for Macintosh, Version 26.0. Armonk, NY, USA).

RESULTS

The distribution of paraspinal muscle atrophy at each intervertebral level for examiner A and examiner B, respectively, is shown in Table 1. The inter-examiner agreement in classification using the LPMAI was significant at all levels ($p<0.001$), ranging from moderate agreement (k=0.69, L3-L4) to substantial agreement (k=0.79, L4-L5) and almost perfect agreement (k=0.86 and 0.88 for L1-L2 and L2-L3, respectively).

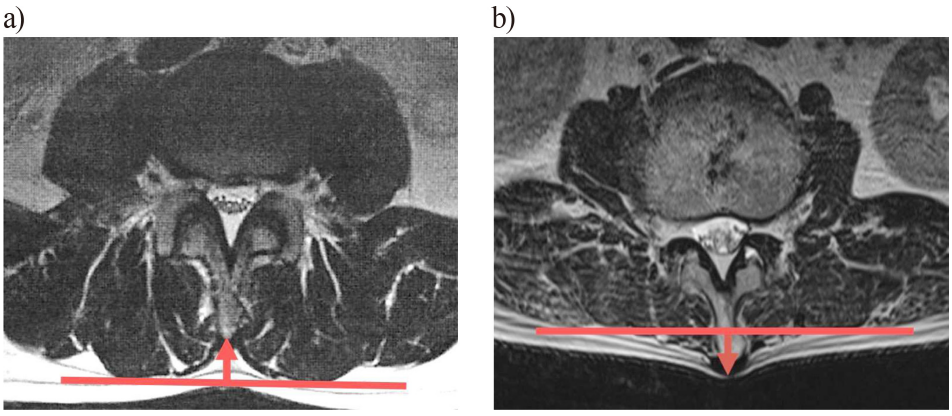

Fig. 1. Evaluation method for L1-2 to L4-5 muscle atrophy on T2-weighted magnetic resonance images used in the study of 225 patients with degenerative lumbar spine disease. The participants of T2 weighted axial images were divided based on the vertical relationship between the line connecting the bilateral bulges of the lumbar paraspinal muscles and the dorsal end of the spinous process: a) Without muscle atrophy; and b) With muscle atrophy. The lumbar indentation value (LIV)[17], representing the distance between bilateral bulges of the lumbar paraspinal muscles and the top of the spinous process, has been reported to be associated with the cross-sectional area of lumbar paraspinal muscles. However, the lumbar paraspinal muscle atrophy index (LPMAI) can visually determine muscle atrophy more easily than the LIV.

Table 1. Presence or absence of high-level muscle atrophy for each intervertebral space and the associated inter-rater reliability in classification

		Examiner A		Examiner B		Inter-rater reliability
		Presence of muscle atrophy (n)	Absence of muscle atrophy (n)	Presence of muscle atrophy (n)	Absence of muscle atrophy (n)	Kappa coefficient
LPMAI	L1/2	190	35	195	30	0.88***
	L2/3	203	22	201	24	0.86***
	L3/4	210	15	206	19	0.49***
	L4/5	210	15	210	15	0.79***

LPMAI: Lumbar paraspinal muscle atrophy index.
***p<0.001.

DISCUSSION

It is estimated that 65–85% of the general population will experience low back pain during their lifetime[19]. Previous studies have reported a smaller CSA of the lumbar paraspinal muscles among individuals with LBP, with a high level of muscle fat infiltration, compared to individuals without LBP[10, 20, 21]. As the mass of the lumbar paraspinal muscles does not decrease with age, spinal disorders are related to a pathological muscle degeneration process rather than to simple disuse muscle atrophy[22, 23]. In physiotherapy, there is evidence of a benefit of trunk muscle strength training for patients with LBP and lumbar disease[24]. As such, evaluation of the status of the lumbar paraspinal muscles would be important in daily clinical practice; this requires a simple method which can be easily implemented in practice. Herein, we showed that the LPMAI provides a simple-to-evaluate parameter of lumbar paraspinal atrophy, with sufficient inter-examiner reliability for practice, except at the L3-4 level. We speculate that the lower kappa coefficient at the L3-4 intervertebral space reflects morphological characteristics of the paravertebral erector spinae muscles and the alignment of the lumbar spine at this segment. Specifically, the erector spinae muscles become thinner in the caudal direction of the lumbar spine, with the multifidus muscle become flatter[25]. Furthermore, Li et al.[26] reported the largest curve of the multifidus-longissimus cleavage planes at the level of the L3 vertebra, with adipose tissue often present in this region of cleavage. We speculate that these morphological characteristics, namely lumbar paraspinal muscle cleavage and existence of fat tissue in the cleavage area, affected the visibility of the line connecting the bilateral bellies of the lumbar paraspinal muscles, lowering the reliability of the LPMAI.

We propose that our novel LPMAI parameter could provide a useful method to detect severe paraspinal muscle atrophy of the lumbar spine in clinical practice with sufficient reliability, except at the L3-4 level. Takayama et al.[17] reported that the LIV represents the depth of the groove between the left and right lumbar spinal muscles, with a high correlation of 0.709 to 0.789, between the LVI and CSA of the lumbar paraspinal muscles at each intervertebral level. Therefore, although the determination of muscle atrophy using the LPMAI remains to be fully established with future research, we consider that a positive LPMAI can be considered to reflect a high degree of atrophy.

Our study has some limitations that require further discussion and investigation. First, participants included in our study group were all treated by posterior lumbar surgeries for degenerative spinal disease and, thus, the majority were older, with the mean age of 64.7 years. Considering the presence of age-related lumbar spine degeneration, there is a possibility that they did not represent a healthy population. The strength of this study is that our analysis included a relatively large number of patients.

In conclusion, our novel LPMAI parameter can identify the presence of severe lumbar paraspinal atrophy, with sufficient inter-examiner reliability. An advantage is that the LPMAI can be easily calculated in busy clinical settings, which could improve the use of lumbar paraspinal atrophy in the treatment planning for individuals with LBP.

Funding and Conflict of interest

The authors declare no conflict of interest. This study was not funded.

REFERENCES

1) Statistics Bureau of Japan: Statistical Handbook of Japan 2021. https://www.stat.go.jp/english/data/handbook/index.html (Accessed Jun. 20, 2022)
2) Deyo RA, Tsui-Wu YJ: Descriptive epidemiology of low-back pain and its related medical care in the United States. Spine, 1987, 12: 264–268. [Medline] [CrossRef]
3) Hurwitz EL, Morgenstern H, Carey TS: The effects of comorbidity and other factors on medical versus chiropractic care for back problems. Spine, 1997, 22: 2254–2263, discussion 2263–2264. [Medline] [CrossRef]
4) Banno T, Yamato Y, Hasegawa T, et al.: Assessment of the cross-sectional areas of the psoas major and multifidus muscles in patients with adult spinal defor-

mity: a case-control study. Clin Spine Surg, 2017, 30: E968–E973. [Medline] [CrossRef]
5) Fortin M, Lazáry À, Varga PP, et al.: Paraspinal muscle asymmetry and fat infiltration in patients with symptomatic disc herniation. Eur Spine J, 2016, 25: 1452–1459. [Medline] [CrossRef]
6) Abbas J, Slon V, May H, et al.: Paraspinal muscles density: a marker for degenerative lumbar spinal stenosis? BMC Musculoskelet Disord, 2016, 17: 422. [Medline] [CrossRef]
7) Ranger TA, Cicuttini FM, Jensen TS, et al.: Paraspinal muscle cross-sectional area predicts low back disability but not pain intensity. Spine J, 2019, 19: 862–868. [Medline] [CrossRef]
8) Lee HJ, Lim WH, Park JW, et al.: The relationship between cross sectional area and strength of back muscles in patients with chronic low back pain. Ann Rehabil Med, 2012, 36: 173–181. [Medline] [CrossRef]
9) Cooper RG, St Clair Forbes W, Jayson MI: Radiographic demonstration of paraspinal muscle wasting in patients with chronic low back pain. Br J Rheumatol, 1992, 31: 389–394. [Medline] [CrossRef]
10) Danneels LA, Vanderstraeten GG, Cambier DC, et al.: CT imaging of trunk muscles in chronic low back pain patients and healthy control subjects. Eur Spine J, 2000, 9: 266–272. [Medline] [CrossRef]
11) Hides JA, Stokes MJ, Saide M, et al.: Evidence of lumbar multifidus muscle wasting ipsilateral to symptoms in patients with acute/subacute low back pain. Spine, 1994, 19: 165–172. [Medline] [CrossRef]
12) Hides JA, Richardson CA, Jull GA: Multifidus muscle recovery is not automatic after resolution of acute, first-episode low back pain. Spine, 1996, 21: 2763–2769. [Medline] [CrossRef]
13) Simmonds AM, Rampersaud YR, Dvorak MF, et al.: Defining the inherent stability of degenerative spondylolisthesis: a systematic review. J Neurosurg Spine, 2015, 23: 178–189. [Medline] [CrossRef]
14) Wan Q, Lin C, Li X, et al.: MRI assessment of paraspinal muscles in patients with acute and chronic unilateral low back pain. Br J Radiol, 2015, 88: 20140546. [Medline] [CrossRef]
15) Sions JM, Elliott JM, Pohlig RT, et al.: Trunk muscle characteristics of the multifidi, erector spinae, psoas, and quadratus lumborum in older adults with and without chronic low back pain. J Orthop Sports Phys Ther, 2017, 47: 173–179. [Medline] [CrossRef]
16) Sions JM, Smith AC, Hicks GE, et al.: Trunk muscle size and composition assessment in older adults with chronic low back pain: an intra-examiner and inter-examiner reliability study. Pain Med, 2016, 17: 1436–1446. [Medline] [CrossRef]
17) Takayama K, Kita T, Nakamura H, et al.: New predictive index for lumbar paraspinal muscle degeneration associated with aging. Spine, 2016, 41: E84–E90. [Medline] [CrossRef]
18) Landis JR, Koch GG: The measurement of observer agreement for categorical data. Biometrics, 1977, 33: 159–174. [Medline] [CrossRef]
19) Andersson GB: Epidemiological features of chronic low-back pain. Lancet, 1999, 354: 581–585. [Medline] [CrossRef]
20) Beneck GJ, Kulig K: Multifidus atrophy is localized and bilateral in active persons with chronic unilateral low back pain. Arch Phys Med Rehabil, 2012, 93: 300–306. [Medline] [CrossRef]
21) Chen YY, Pao JL, Liaw CK, et al.: Image changes of paraspinal muscles and clinical correlations in patients with unilateral lumbar spinal stenosis. Eur Spine J, 2014, 23: 999–1006. [Medline] [CrossRef]
22) Shahidi B, Parra CL, Berry DB, et al.: Contribution of lumbar spine pathology and age to paraspinal muscle size and fatty infiltration. Spine, 2017, 42: 616–623. [Medline] [CrossRef]
23) Fortin M, Yuan Y, Battié MC: Factors associated with paraspinal muscle asymmetry in size and composition in a general population sample of men. Phys Ther, 2013, 93: 1540–1550. [Medline] [CrossRef]
24) Handa N, Yamamoto H, Tani T, et al.: The effect of trunk muscle exercises in patients over 40 years of age with chronic low back pain. J Orthop Sci, 2000, 5: 210–216. [Medline] [CrossRef]
25) Sasaki T, Yoshimura N, Hashizume H, et al.: MRI-defined paraspinal muscle morphology in Japanese population: The Wakayama Spine Study. PLoS One, 2017, 12: e0187765. [Medline] [CrossRef]
26) Li H, Yang L, Chen J, et al.: Magnetic resonance imaging-based anatomical study of the multifidus-longissimus cleavage planes in the lumbar spine. Am J Transl Res, 2016, 8: 109–116. [Medline]