

# Nocturnal Leg Cramps and Lumbar Spinal Stenosis: A Cross-Sectional Study in the Community

Junichi Handa, Koji Otani , Takuya Nikaido , Shin-ichi Kikuchi<sup>†</sup>, Shin-ichi Konno

Department of Orthopaedic Surgery, Fukushima Medical University School of Medicine, Fukushima, Japan

<sup>†</sup>Shin-ichi Kikuchi passed away on February 22th, 2022

Correspondence: Junichi Handa, Tel +81-24-547-1276, Fax +81-24-548-5505, Email hanhan@fmu.ac.jp

**Purpose:** Nocturnal leg cramps are considered to be a symptom of lumbar spinal stenosis (LSS). However, the relationship between LSS and nocturnal leg cramps in the general population remains unclear. The purpose of this study was to investigate the prevalence and characteristics of nocturnal leg cramps in LSS in the community.

**Patients and Methods:** 328 voluntary participants were enrolled in this study. The presence of LSS was assessed by a validated and self-administered diagnostic support tool. The presence of nocturnal leg cramps and neurological findings were evaluated by one experienced spine surgeon. To investigate the relationship between leg cramps and anatomical factors, the participants underwent an MRI scan, and the dural sac cross-sectional area (DCSA) at each lumbar intervertebral disc level was measured.

**Results:** A total of 214 participants (65.2%) had nocturnal leg cramps, and 94 of 328 participants (28.7%) showed typical LSS symptoms. In the typical LSS symptom group, 31 participants (33.0%) had nocturnal leg cramps. In the atypical LSS symptom group, 83 participants (35.5%) had nocturnal leg cramps. There was no statistically significant difference in the prevalence of nocturnal leg cramps between the two groups. The narrowest DCSA ( $<25 \text{ mm}^2$  and  $25\text{--}49.4 \text{ mm}^2$ ) was statistically related to the presence of nocturnal leg cramp. Statistically significant differences in sensory disturbance and motor weakness were not observed between the subjects with and those without nocturnal leg cramps. Moreover, impaired PTR was statistically related to the presence of nocturnal leg cramp.

**Conclusion:** The prevalence of nocturnal leg cramps did not differ with or without typical LSS symptoms in the community. The degree of dural tube compression that is determined by DCSA had a direct effect on the presence of nocturnal leg cramps. Neurological impairment, such as PTR abnormalities, was associated with the presence of nocturnal leg cramps.

**Keywords:** nocturnal leg cramps, lumbar spinal stenosis, general population, magnetic resonance imaging, sensory disturbance, motor weakness

## Introduction

Lumbar spinal stenosis (LSS) causes various lower extremity symptoms, such as neurogenic intermittent claudication, radicular leg pain, and leg numbness. In addition to these symptoms, patients with LSS often complain of nocturnal leg cramps.<sup>1–3</sup>

Nocturnal leg cramps are recurrent painful muscle cramps, affecting the calf, the thighs, or foot muscles.<sup>4–6</sup> They occur suddenly and usually last up to 4–5 minutes.<sup>5</sup> The prevalence of nocturnal leg cramps has been reported as 35–60% in the general population and 50% in the elderly outpatient population.<sup>7–11</sup> The exact pathogenesis of nocturnal leg cramps is still unclear; however, it has been reported that nocturnal leg cramps are associated with medical conditions such as vascular disease, cirrhosis, hemodialysis, pregnancy, and LSS.<sup>4,5,12</sup>

Recently, some studies have reported the relationship between nocturnal leg cramps and LSS. In a questionnaire survey on leg cramps for patients with LSS, nocturnal leg cramps were more prevalent in LSS patients than in the elderly population.<sup>1</sup> Another study has also reported that nocturnal leg cramps were significantly more frequent in LSS patients than in controls.<sup>2</sup> However, in those studies, the subjects were hospital patients. The relationship between nocturnal leg

cramps and LSS in the general population has not yet been clarified. Furthermore, the details of subjects with nocturnal leg cramps and LSS in the general population have also not yet been elucidated.

On the other hand, it has been reported by a population-based study in Japan that the prevalence of subjects with LSS aged > 40 years was 5.7%.<sup>13</sup> The number of LSS patients will increase in the aging society in the near future. Therefore, because both have a high prevalence in the general population, it is important to investigate the relationship between nocturnal leg cramps and LSS. Furthermore, it is also well-known that anatomical stenosis does not always produce symptoms.<sup>14–16</sup>

The purpose of the present study was to investigate the prevalence of nocturnal leg cramps in subjects with symptomatic LSS, and to clarify the relationship between nocturnal leg cramps and symptomatic LSS or anatomical stenosis on MRI in the community.

## Materials and Methods

### Ethics

This study was approved by the Ethics Committee of Fukushima Medical University and was conducted in accordance with the Declaration of Helsinki.

### Study Design

The study design was a cross-sectional study. This survey was conducted by the respective local government offices of Tadami town and Ina village in Fukushima Prefecture, Japan, in 2004.<sup>17</sup> In brief, subjects were recruited from the respondents to an announcement of assessment of LSS that was part of a public health survey being conducted by their local governments. All subjects were self-sufficient (living in their own houses without the need for supplemental care, and able to walk independently with or without support such as a cane or a walker). Subjects were excluded if they were unable to fill out the questionnaires by themselves, had ever undergone brain or spinal surgery, or had experienced a fracture of the lower extremities in the year previous to the start of the study period.

### Assessment

Written informed consent was obtained from all participants.

### Definition of Typical LSS Symptoms

To examine the presence or absence of lower extremity symptoms caused by LSS, the physicians used a diagnostic support tool for LSS, which is a self-administered, self-reported history questionnaire (LSS-SSHQ) ([Supplementary Data 1](#)). The LSS-SSHQ consists of 10 yes/no question items,<sup>18</sup> and each item requires a response of either “1 = yes” or “0 = no”. A total score of 4 for Q1–Q4, or a score  $\geq 1$  for Q1–Q4 combined with  $\geq 2$  for Q5–Q10, indicated the presence of LSS.<sup>18</sup> The sensitivity and specificity of the LSS-SSHQ have been confirmed to be 0.855 and 0.791, respectively, in the derivation data, and 0.843 and 0.781, respectively, in the validation data.<sup>18</sup> The area under the receiver operating characteristic curve was 0.797 in the derivation data set and 0.782 in the validation data set.<sup>18</sup> This questionnaire is suitable for epidemiological studies because it can eliminate differences in diagnosis due to different attending physicians.<sup>19,20</sup>

### Evaluation of Nocturnal Leg Cramps

To evaluate of the presence or absence of nocturnal leg cramps, all participants were interviewed by one board-certificated spine surgeon who asked them if they had experienced cramps in their legs at night within the previous month. In the present study, we investigated only the presence or absence of nocturnal leg cramps, and did not examine the frequency or the details of the site of onset.

### Neurological Findings

All participants received neurological examinations from one board-certificated spine surgeon in order to investigate sensory disturbance and motor weakness of the lower extremities. These diagnoses were made after examination of superficial sensation and a manual muscle testing. To assess sensory disturbance, the physician performed light touch stimulation of the lower extremities, and the participants judged the intensity of the sensation. In the manual muscle

testing, motor weakness was categorized when the result was  $\leq 4$  on a grading scale of 0–5. In addition, the patellar tendon reflex (PTR) and the Achilles tendon reflex (ATR) were examined for muscle stretch reflexes in the lower extremities. In the present study, in order to evaluate the effect of LSS on the muscle stretch reflex as an objective finding, a difference between the left and right side or the disappearance of both sides was considered as impairment, and the other cases were considered normal.

### The Imaging Studies by MRI

To evaluate anatomical factors, MRI was performed on all participants. The dural sac cross-sectional area (DCSA) at each lumbar intervertebral disc level from the first lumbar vertebra to the first sacral vertebra was calculated from transverse-slice lumbosacral MRI (T2 weighted image) ([Supplementary data 2](#)) using the formulae reported by Hamanishi et al.<sup>21</sup> The narrowest cross-sectional area of the lumbar dural tube was used for analysis. Furthermore, the number of dural tubes with cross-sectional areas of  $< 50 \text{ mm}^2$  was used for analysis. If they were  $< 50 \text{ mm}^2$ , then the subject was morphologically diagnosed with typical LSS.<sup>22</sup>

### Statistical Analysis

The chi-square test was used to compare all of the subject items except for age, and the Mann–Whitney *U*-test was used to compare age between the positive and the negative nocturnal leg cramp group. The crude analysis was done using single-variate logistic regressions to evaluate the statistical association between the presence of nocturnal leg cramps as the dependent variable and each explanatory variable such as gender (male, female), age (continuous variable), presence of typical LSS symptoms (positive, negative), narrowest DCSA ( $< 25 \text{ mm}^2$ , 25–49.9, 50–74.9, 75–99.9 and  $\geq 100$ ), number of DCSA  $< 50 \text{ mm}^2$  (continuous variable), sensory disturbance (positive, negative), motor weakness (positive, negative), PTR (normal, impaired) and ATR (normal, impaired). In addition, multivariate logistic regression analysis was performed, adjusting for age and gender and including all explanatory variables. A *p* value of  $< 0.05$  was considered statistically significant. All statistical analyses were performed using the STAT View software package (version 5.0, SAS Institute Inc., Cary, NC).

## Results

### Participant Characteristics

The participant characteristics are shown in [Table 1](#). A total of 328 subjects (105 males and 223 females) were enrolled in this study. Their age ranged 28–86 years old, and most subjects were in their 70s. One hundred fourteen participants (34.8%) had nocturnal leg cramps, and 94 (28.7%) of whom showed typical LSS symptoms.

On MRI evaluation, 113 participants had a narrowest DCSA of  $< 50 \text{ mm}^2$ . Neurological findings showed sensory disturbance in 39 participants (11.9%), motor weakness in 51 (15.6%), PTR impairment in 44 (13.6%), and ATR impairment in 107 (32.9%).

### Comparison of Characteristics Between with and without Nocturnal Leg Cramps Gender and Age

Among the males, 40 participants (38.1%) experienced nocturnal leg cramps. Among the females, 74 participants (33.2%) had nocturnal leg cramps. Thus, there was no statistically significant difference in the prevalence of nocturnal leg cramps by gender ( $p = 0.3835$ ). Similarly, there was no significant difference in age ( $p = 0.2924$ ) ([Table 2](#)).

### LSS Symptoms

In the typical LSS symptom positive and negative groups, 31 (33.0%) and 83 (35.5%) participants, respectively, had nocturnal leg cramps. Therefore, there was no statistically significant difference in the prevalence of nocturnal leg cramps between the two groups ( $p = 0.6683$ ) ([Table 2](#)).

### Anatomical Factors

There was no statistically significant difference between the presence of nocturnal leg cramps and the narrowest DCSA ( $p = 0.2949$ ). Similarly, there was no statistically significant difference between the presence of nocturnal leg cramps and number of DCSAs that were  $< 50 \text{ mm}^2$  ( $p = 0.2494$ ) ([Table 2](#)).

**Table 1** Participant Characteristics

		<b>N</b>	<b>%</b>
Gender	Male	105	32.0
	Female	223	68.0
Age (years old)	< 40	13	4.0
	40–49	13	4.0
	50–59	48	14.6
	60–69	109	33.2
	70–79	121	36.9
	≥ 80	24	7.3
Nocturnal leg cramp	Positive	114	34.8
	Negative	214	65.2
Typical LSS symptoms	Positive	94	28.7
	Negative	234	71.3
Narrowest DCSA (mm <sup>2</sup> )	< 25	35	10.7
	25–49.9	78	23.8
	50–74.9	81	24.7
	75–99.9	52	15.9
	≥ 100	82	25.0
Number of DCSA < 50mm <sup>2</sup>	0	213	64.9
	1	69	21.0
	2	35	10.7
	3	11	3.4
Sensory disturbance	Positive	39	11.9
	Negative	288	88.1
Motor weakness	Positive	51	15.6
	Negative	276	84.4
PTR	Normal	279	86.4
	Impaired	44	13.6
ATR	Normal	218	67.1
	Impaired	107	32.9

## Neurological Findings

In the positive and negative sensory disturbance groups, 16 (41.0%) and 98 (34%) participants, respectively, had nocturnal leg cramps. Thus, there was no statistically significant difference in the prevalence of nocturnal leg cramps between the two groups ( $p = 0.3894$ ). Similarly, there was no statistically significant difference between motor weakness and the presence of nocturnal leg cramps ( $p = 0.5692$ ). On the other hand, in the PTR normal and PTR impairment

**Table 2** Comparison of Characteristics Between Participants with and without Nocturnal Leg Cramp

		Nocturnal Leg Cramp				p value
		Positive N (%)		Negative N (%)		
Total		114	(34.8)	214	(65.2)	
Gender	Male	40	(35.1)	65	(30.4)	0.3835
	Female	74	(64.9)	149	(69.6)	
Age (average ± S.D.)		67.0 ± 10.1		65.6 ± 12.1		0.2924
Typical LSS symptom	Positive	31	(27.2)	63	(29.4)	0.6683
	Negative	83	(72.8)	151	(70.6)	
Narrowest DCSA (mm <sup>2</sup> )	< 25	16	(14.0)	19	(8.9)	0.2949
	25–49.9	29	(25.4)	49	(22.9)	
	50–74.9	21	(18.4)	60	(28.0)	
	75–99.9	19	(16.7)	33	(15.4)	
	≥ 100	29	(25.4)	53	(24.8)	
Number of DCSA < 50mm <sup>2</sup>	0	69	(60.5)	144	(67.2)	0.2494
	1	31	(27.2)	38	(17.8)	
	2	11	(9.6)	24	(11.2)	
	3	3	(2.6)	8	(3.7)	
Sensory disturbance	Positive	16	(14.0)	23	(10.7)	0.3894
	Negative	98	(86.0)	190	(88.8)	
Motor weakness	Positive	16	(14.0)	35	(16.4)	0.5692
	Negative	98	(86.0)	178	(83.2)	
PTR	Normal	89	(78.1)	190	(88.8)	0.0034
	Impaired	24	(21.1)	20	(9.3)	
ATR	Normal	69	(60.5)	149	(69.6)	0.0921
	Impaired	44	(38.6)	63	(29.4)	

groups, 89 (31.9%) and 24 (54.5%) participants, respectively, had nocturnal leg cramps. There was a statistically significant difference in the prevalence of nocturnal leg cramps between the two groups ( $p < 0.05$ ). Similarly, in the ATR normal and ATR impairment group, 44 (41.1%) and 69 (31.7%) participants, respectively, had nocturnal leg cramps, but the difference was not significant ( $p = 0.0921$ ) (Table 2).

## Related Factors with Prevalence of Nocturnal Leg Cramps

In multivariate logistic regression adjusted for age and gender, the narrowest DCSA (< 25 mm<sup>2</sup> and 25–49.4 mm<sup>2</sup>) and PTR impairments were determined to be statistically related to the presence of nocturnal leg cramps (Table 3).

**Table 3** Associations of Individual Factors with Prevalence of Night Cramp

		Crude Analysis			Adjusted Analysis		
		OR	95% CI	p value	OR	95% CI	p value
Gender	Male	Ref.			Ref.		
	Female	0.807	0.498–1.308	0.3839	0.833	0.497–1.396	0.4887
Age		1.011	0.991–1.032	0.2923	1.007	0.985–1.030	0.5245
Typical LSS symptom	Positive	0.895	0.539–1.486	0.6684	0.733	0.403–1.353	0.3082
	Negative	Ref.			Ref.		
Narrowest DCSA (mm <sup>2</sup> )	< 25	1.539	0.688–3.441	0.2935	4.239	1.013–17.747	0.0480
	25–49.9	1.082	0.568–2.061	0.8115	2.148	0.699–6.601	0.1818
	50–74.9	0.640	0.327–1.253	0.1927	0.624	0.310–1.255	0.1857
	75–99.9	1.052	0.510–2.170	0.8903	1.051	0.497–2.225	0.8956
	≥ 100	Ref.			Ref.		
Number of DCSA less than 50mm <sup>2</sup>		1.046	0.793–1.379	0.7522	0.534	0.275–1.035	0.0632
Sensory disturbance	Positive	1.349	0.681–2.670	0.3907	1.296	0.585–2.874	0.5228
	Negative	Ref.			Ref.		
Motor weakness	Positive	0.83	0.437–1.576	0.5695	0.725	0.348–1.512	0.391
	Negative	Ref.			Ref.		
PTR	Normal	Ref.			Ref.		
	Impaired	2.562	1.345–4.881	0.0042	2.46	1.238–4.890	0.0102
ATR	Normal	Ref.			Ref.		
	Impaired	1.508	0.934–2.436	0.929	1.419	0.835–2.411	0.196

**Notes:** The crude analysis used single-variate logistic regressions. The adjusted analysis used multivariate logistic regression including all explanatory variable.

## Discussion

The epidemiological studies on nocturnal leg cramps that have been reported so far have been mainly conducted on outpatients and not on community residents. The prevalence of nocturnal leg cramps has been reported to be 35–60%.<sup>7–11</sup> The etiology of the cramps was classified into lower motor neuron disorders, metabolic disorders, acute extracellular volume depletion, medication, hereditary disorders and no apparent cause (ex. nocturnal leg cramp in the elderly, exercise-related).<sup>10</sup> According to these classifications, nocturnal leg cramp associated with LSS is considered to belong to lower motor neuron disorders. From the viewpoint of nerve root compression, Nishant et al proposed the pathogenesis of leg cramps in LSS. However, a variety of etiologies have been considered for the pathogenesis of nocturnal leg cramps, and its high prevalence suggests that the pathogenesis of nocturnal leg cramps is complex. Therefore, LSS seems to be just one of the pathogeneses of nocturnal leg cramps.

In the present study, we set out to clarify the prevalence and characteristics of nocturnal leg cramps with LSS in the community. Several previous studies have reported on the relationship between leg cramps and LSS.<sup>1–3</sup> However, in all of these studies, the subjects were in the hospital setting. To our knowledge, this is the first study to investigate the relationship between nocturnal leg cramps and LSS in the community.

In the present study, nocturnal leg cramp was not significantly higher in the typical LSS symptom group in the community (33.0% in the typical LSS symptoms group, 35.5% in atypical LSS symptoms group). On the other hand, Matsumoto et al and Nishant et al reported that nocturnal leg cramps are more prevalent in postoperative or conservatively treated LSS patients than in the general elderly population.<sup>1,2</sup> One of the reasons for this discrepancy was that these studies were hospital-based and the symptoms of LSS should be more serious than those of our study. Furthermore, there was no statistically significant difference in the prevalence of nocturnal leg cramps by gender or age evaluated by single-/multivariate logistic regression analysis in the study. According to a general population survey, the prevalence of rest cramps was substantially higher in older subjects than in younger subjects.<sup>8</sup> Another study has also reported that high frequency of nocturnal leg cramps was due to female predominance and age distribution.<sup>23</sup> In general, nocturnal leg cramps are considered to be slightly more common in females, and the prevalence increases with age.<sup>4,7</sup> There is currently no logical explanation for the discrepancy between this study and previous studies, and further research is needed to resolve it.

In the present study, the relationship between nocturnal leg cramps and anatomical factors measured by MRI of the cross-sectional area of the lumbar dural tube showed that nocturnal leg cramps increased with the degree of anatomical stenosis. Several studies have reported that nerve root compression may be an underlying cause of nocturnal leg cramps.<sup>2,6,24,25</sup> Ohtori et al also reported that the prevalence of nocturnal leg cramps is associated with spinal nerve compression and symptom severity in patients with LSS.<sup>3</sup> The results of the current study regarding this are consistent with those of previous reports. Moreover, in the present study, DCSA of  $< 50 \text{ mm}^2$  was shown for the first time to be an independent factor in the development of nocturnal leg cramps, regardless of typical LSS symptoms, by multivariate logistic analysis, which is considered to be statistically more robust than univariate analysis.

Looking at the relationship between nocturnal leg cramps and neurological findings, the presence of sensory disturbance or motor weakness in the lower extremities did not make a significant difference in the prevalence of nocturnal leg cramp. In the muscle stretch reflexes, PTR impairment has often been reported to be associated with nocturnal leg cramps. Haskell et al reported the prevalence of peripheral neurological deficit showing one of the most striking differences between patients with cramps and the control group.<sup>26</sup> The results of the present study and those of previous reports suggest that some neurological dysfunctions are associated with the presence of nocturnal leg cramps.<sup>4</sup> However, the question arises as to why the impairment of PTR, not ATR, was related to be statistically associated with nocturnal leg cramps. In general, the neurological finding of LSS is that ATR is more compromised than PTR.<sup>27</sup> However, similarly, in the general population, ATR is more severely impaired than PTR with aging, especially in people aged  $\geq 60$ .<sup>28,29</sup> Therefore, since ATR impairment is strongly affected by aging as well as LSS, PTR impairment that are less affected by aging compared with ATR may be detected as non-aging neurological abnormalities.

In the present study, 33.0% of residents with positive nocturnal leg pain showed typical LSS symptoms and 39.8% had a DCSA  $< 50 \text{ mm}^2$  (Table 2). Approximately 30–40% of the residents who complain of nocturnal leg cramps had typical LSS symptoms or anatomical LSS with a DCSA of  $< 50 \text{ mm}^2$ , suggesting that it is reasonable to consider the presence of symptomatic LSS or anatomical LSS when seeing elderly patients who complain of nocturnal leg cramps, but not a screening tool to suspect typical LSS symptoms or anatomical LSS. In other words, a reasonable interpretation would be to recognize that the presence of typical LSS symptoms and asymptomatic anatomical LSS is one of the relevant factors in the development of nocturnal leg cramps. In clinical practice, LSS-specific treatments may be effective for some patients who complain of nocturnal leg cramps, rather than traditional treatments such as drugs and stretching exercises. Further study into this issue is needed.

This study has some limitations. Firstly, as an epidemiological study, the number of subjects was relatively small. Secondly, other comorbidities were not investigated. It has been reported that nocturnal leg cramps are associated with other medical conditions;<sup>4</sup> however, the exact mechanism of nocturnal leg cramps is still unclear. Therefore, it might be difficult to exclude all other comorbidities that are possible causes of nocturnal leg cramps. For example, electrolyte status, including serum calcium, which has been implicated in nocturnal cramps, has not been investigated. Furthermore, in addition to comorbidities, cold stimulation to the leg muscles may also induce leg cramp. It is difficult to exclude this factor because it is difficult to interview all possible cold exposures as well. Thirdly, the LSS-SSHQ was used as a screening tool for LSS. Not all subjects with LSS symptoms were found by LSS-SSHQ. Due to the sensitivity and



specificity of the LSS-SSHQ, it is impossible to evaluate all forms of LSS, including asymptomatic LSS, in this study. Regarding the specificity of the LSS-SSHQ, approximately 20% of subjects diagnosed with typical LSS symptoms were suspected to be a false positive. And it did not examine whether leg symptoms were unilateral or bilateral. Fourthly, this study measured at the DCSA on MRI images and did not consider the lumbar disc herniation or foraminal stenosis. The assessment of radiological LSS in this study was limited to central LSS. Fifthly, the survey area was based in the countryside of Japan and all of the participants in this study were volunteers. Therefore, the data might not extrapolate completely to the general Japanese population and there might be a selection bias. The prevalence of LSS defined by LSS-SSHQ in this study was 28.7%. This rate is much higher than other cohorts in the general population.<sup>13,30</sup> This might be due to the fact that the countryside has a high aging population, and subjects were recruited who wanted to be surveyed for LSS. Finally, since it was a cross-sectional study, it was shown that there was a relationship between typical LSS symptoms and nocturnal leg pain, but it was not possible to clarify whether the presence of typical LSS symptoms was responsible for the presence of nocturnal leg pain.

## Conclusion

Nocturnal leg cramps were not more frequent in subjects with typical LSS symptoms than in those without typical LSS symptoms in the community. The degree of dural tube compression, which is determined by DCSA, had a direct effect on the presence of nocturnal leg cramps. Furthermore, neurological disturbance, such as PTR impairment, was associated with the presence of nocturnal leg cramps.

## Acknowledgments

This study was supported by a grant from the Fukushima Society for the Promotion of Medicine and a grant from Fukushima Prefectural Hospitals Office.

## Disclosure

The authors report no conflicts of interest in this work.

## References

1. Matsumoto M, Watanabe K, Tsuji T, et al. Nocturnal leg cramps: a common complaint in patients with lumbar spinal canal stenosis. *Spine*. 2009;34:E189–E194. doi:10.1097/BRS.0b013e31818f953c
2. Chhabra HS, Kapoor KS, Kapoor KS. Nocturnal cramps in patients with lumbar spinal canal stenosis treated conservatively: a prospective study. *Asian Spine J*. 2014;8:624–631. doi:10.4184/asj.2014.8.5.624
3. Ohtori S, Yamashita M, Murata Y, et al. Incidence of nocturnal leg cramps in patients with lumbar spinal stenosis before and after conservative and surgical treatment. *Yonsei Med J*. 2014;55:779–784. doi:10.3349/ymj.2014.55.3.779
4. Allen RE, Kirby KA. Nocturnal leg cramps. *Am Fam Physician*. 2012;86:350–355.
5. Butler JV, Mulkerrin EC, O'Keeffe ST. Nocturnal leg cramps in older people. *Postgrad Med J*. 2002;78:596–598. doi:10.1136/pmj.78.924.596
6. Monderer RS, Wu WP, Thorpy MJ. Nocturnal Leg Cramps. *Curr Neurol Neurosci Rep*. 2010;10:53–59. doi:10.1007/s11910-009-0079-5
7. Abdulla AJ, Jones PW, Pearce VR. Leg cramps in the elderly: prevalence, drug and disease associations. *Int J Clin Pract*. 1999;53:494–496.
8. Naylor JR, Young JB. A general population survey of rest cramps. *Age Ageing*. 1994;23:418–420. doi:10.1093/ageing/23.5.418
9. Oboler SK, Prochazka AV, Meyer TJ. Leg symptoms in outpatient veterans. *West J Med*. 1991;155:256–259.
10. Miller TM, Layzer RB. Muscle cramps. *Muscle Nerve*. 2005;32:431–442. doi:10.1002/mus.20341
11. Maisonneuve H, Chambe J, Delacour C, et al. Prevalence of cramps in patients over the age of 60 in primary care: a cross sectional study. *BMC Fam Pract*. 2016;17:111. doi:10.1186/s12875-016-0509-9
12. Konikoff F, Theodor E. Painful muscle cramps. A symptom of liver cirrhosis? *J Clin Gastroenterol*. 1986;8:669–672. doi:10.1097/00004836-198612000-00017
13. Yabuki S, Fukumori N, Takegami M, et al. Prevalence of lumbar spinal stenosis, using the diagnostic support tool, and correlated factors in Japan: a population-based study. *J Orthop Sci*. 2013;18:893–900. doi:10.1007/s00776-013-0455-5
14. Wiesel SW, Tsourmas N, Feffer HL, et al. A study of computer-assisted tomography. I. The incidence of positive CAT scans in an asymptomatic group of patients. *Spine*. 1984;9(6):549–551. doi:10.1097/00007632-198409000-00003
15. Boden SD, Davis DO, Dina TS, et al. Abnormal magnetic-resonance scans of the lumbar spine in asymptomatic subjects. A prospective investigation. *J Bone Joint Surg Am*. 1990;72:403–408. doi:10.2106/00004623-199072030-00013
16. Jensen MC, Brant-Zawadzki MN, Obuchowski N, et al. Magnetic resonance imaging of the lumbar spine in people without back pain. *N Engl J Med*. 1994;331(2):69–73. doi:10.1056/NEJM199407143310201
17. Otani K, Kikuchi S, Yabuki S, et al. Prospective one-year follow-up of lumbar spinal stenosis in a regional community. *J Pain Res*. 2018;11:455–464. doi:10.2147/JPR.S148402



18. Konno S, Kikuchi S, Tanaka Y, et al. A diagnostic support tool for lumbar spinal stenosis: a self-administered, self-reported history questionnaire. *BMC Musculoskelet Disord*. 2007;8:102. doi:10.1186/1471-2474-8-102
19. Kato K, Sekiguchi M, Yonemoto K, et al. Diagnostic accuracy of the Self-administered, Self-reported History Questionnaire for lumbar spinal stenosis patients in Japanese primary care settings: a multicenter cross-sectional study (DIS-TO-project). *J Orthop Sci*. 2015;20:805–810. doi:10.1007/s00776-015-0740-6
20. Otani K, Kikuchi S, Yabuki S, et al. Lumbar spinal stenosis has a negative impact on quality of life compared with other comorbidities: an epidemiological cross-sectional study of 1862 community-dwelling individuals. *ScientificWorldJournal*;2013. 590652. doi:10.1155/2013/590652
21. Hamanishi C, Matukura N, Fujita M, et al. Cross-sectional area of the stenotic lumbar dural tube measured from the transverse views of magnetic resonance imaging. *J Spinal Disord*. 1994;7(5):388–393. doi:10.1097/00002517-199410000-00004
22. Lønne G, Ødegård B, Johnsen LG, et al. MRI evaluation of lumbar spinal stenosis: is a rapid visual assessment as good as area measurement? *Eur Spine J*. 2014;23(6):1320–1324. doi:10.1007/s00586-014-3248-4
23. Manila MN. Leg cramps in relation to metabolic syndrome. *Georgian Med News*. 2009;166:51–54.
24. Sugar O. Causes of night cramps. *JAMA*. 1985;253:775–776. doi:10.1001/jama.1985.03350300061008
25. Rish BL. Nerve root compression and night cramps. *JAMA*. 1985;254:361. doi:10.1001/jama.1985.03360030051019
26. Haskell SG, Fiebach NH. Clinical epidemiology of nocturnal leg cramps in male veterans. *Am J Med Sci*. 1997;313:210–214. doi:10.1097/0000441-199704000-00003
27. Jönsson B, Strömquist B. Symptoms and signs in degeneration of the lumbar spine. A prospective, consecutive study of 300 operated patients. *J Bone Joint Surg Br*. 1993;75:381–385. doi:10.1302/0301-620X.75B3.8496204
28. Bowditch MG, Sanderson P, Livesey JP. The significance of an absent ankle reflex. *J Bone Joint Surg Br*. 1996;78:276–279. doi:10.1302/0301-620X.78B2.0780276
29. Nikaido T, Kikuchi S, Yabuki S, et al. Epidemiological studies on the locomotor system- Minami-Aizu Study, the sixth report; Epidemiology of deep tendon reflex. *Rinsho Seikei Geka*. 2010;45:43–49. Japanese.
30. Jensen RK, Jensen TS, Kose B, et al. Prevalence of lumbar spinal stenosis in general and clinical populations: a systematic review and meta-analysis. *Eur Spine J*. 2020;29:2143–2163. doi:10.1007/s00586-020-06339-1

## International Journal of General Medicine

Dovepress

### Publish your work in this journal

The International Journal of General Medicine is an international, peer-reviewed open-access journal that focuses on general and internal medicine, pathogenesis, epidemiology, diagnosis, monitoring and treatment protocols. The journal is characterized by the rapid reporting of reviews, original research and clinical studies across all disease areas. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/international-journal-of-general-medicine-journal>