J. Phys. Ther. Sci.
23: 625–627, 2011

Muscle Strength During Active Straight Leg Raising Correlates with Walking Capacity in Patients with Lumbar Spinal Canal Stenosis with Neurogenic Intermittent Claudication

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Abstract. [Purpose] The purpose of this study was to investigate the factors related to walking capacity (WC) reflecting neurogenic intermittent claudication (IC). [Subjects and Methods] We selected 56 female patients (69.6 ± 8.0 years) with Lumber Spinal Canal Stenosis (LCS) with IC. We measured WC on a flat floor, and demonstrated that 3 factors predict the relationship with IC as follows: trunk forward bending in the standing position (finger-floor distance), muscle strength during active straight leg raising (ASLR) on the symptomatic side, and the degree of subjective pain soon after standing upright for 30 s. [Results] WC and muscle strength in ASLR were not affected by age. WC was correlated with ASLR strength. [Conclusion] These results suggest that the motion of ASLR leads to canal or foraminal stenosis, and that this test will be useful for patients with LCS.
Key words: Lumbar spinal canal stenosis, Walking capacity, Muscle strength during active straight leg raising

(This article was submitted Feb. 16, 2011, and was accepted Mar. 29, 2011)

INTRODUCTION

Lumbar spinal canal stenosis (LCS) is a major cause of low back pain. This syndrome is a pathological condition that compresses cauda or spinal nerve roots, and is caused by degenerative changes in the facet joints, intervertebral disks, or ligamentum flavum in one or several segments of the lumbar spine[1)]. In the United States, LCS was the most common indication for lumbar spinal surgery in elderly persons in 1992[2)]. There were more than 30,000 surgeries, and their total cost reached almost $1 billion in 1996[3,4)]. The latest data in Japan has not been reported, but we know, LCS is a medical and socioeconomic problem.

Lumbar stenosis induced symptoms are defined as buttock or leg pain, paresthesia, or cramping when standing upright or walking. These symptoms are decreased by forward bending[5)]. One of the principal symptoms of LCS is neurogenic intermittent claudication (IC). The prevalence of IC in patients with LCS is reported to range from 46.7 to 94%[6–9)]. It has been hypothesized that the appearance of IC is the result of direct mechanical compression of the nerve[10)], relative ischemia[11)] or venous stasis[12)] in microcirculation of the spinal nerve root or cauda equina. Patients with IC are greatly restricted in daily living because of their narrow range of activities[13)], and it often leads to psychological problems or a decline in the quality of life[14)]. Thus, the evaluation of IC is essential in this disease. The measurement of IC in previous studies has roughly been divided between two methods: questionnaire and measurement of actual walking capacity (WC). However, Zeifang et al.[15)] showed that self-reported WC in questionnaire surveys did not correspond to actual WC. On the other hand, measurement of actual WC causes great pain for patients and takes much time. Therefore, a substitute test which causes less pain and takes less time for actual WC is needed. The purpose of the current study was to investigate factors related to actual WC in patients with LCS.

SUBJECTS AND METHODS

Subjects

We selected 56 patients (69.6 ± 8.0 years; BMI, 24.1 ± 2.9 kg/m^2) with degenerative LCS for this study. The inclusion criteria was as follows: existence of IC, presence of L4/5 level stenosis, no pain or neurological deficit at rest, younger than 80 years old, female, and ability to walk without any aid. All patients underwent a physical examination conducted by a physical therapist, and they provided their consent to the use of their data in this study.

Methods

We evaluated IC and 3 factors expected to relate to IC as follows: trunk forward bending in the standing position (finger-floor distance; FFD), muscle strength during active straight leg raising (ASLR) on the symptomatic side, and subjective pain immediately after upright standing for 30 s evaluated using a visual analogue scale (VAS).

We measured actual WC reflected IC. Patients were asked to shuttle continuously for 25 meter on flat ground without rest until they could not tolerate the neurological symptoms (pain, numbness, and lassitude). For the measurement of WC, subjects walked at their natural speed without excess trunk forward bending. There were no patients who could not walk because of joint pain in the lower extremity, palpitation, or dyspnea. All patients symptoms were improved by a few minutes rest.

FFD reflects not only tightness of the knee flexor muscles (hamstrings) but also the mobility of lumbar kyphosis. We used a Flexibilimeter (TKK.5003, Takei Kiki Kougyou) to measure FFD. Patients stood in an upright position and began to slowly bend their trunk forward with their knees extended and their heels touching the floor. They reached with their middle finger as close as possible to the ground. Then, they attempted the task again with a bent knee or elevated heel. Two attempts were made and the lower value of these two attempts was adopted (a negative value indicates better flexibility).

We used ASLR to evaluate muscle strength on the symptomatic lower extremity. The ASLR test was used to determine for the subjective pain on the pelvic girdle[16]. This test has been frequently used pregnant women with loose pelvic joints[17], and its reliability and validity have been validated[18]. In our study, we measured muscle strength in ASLR with a hand-held dynamometer (HHD). Patients lay in the supine position and were asked to flex their hip at 30° with the knee extended on the symptomatic side and the opposite hip and knee joints extended straight on the floor. The HHD was attached to the center of the distal crus, and when instructed, patients tried to elevate the leg to the attachment as much as possible for 3 s (break test). The reliability of this measurement was confirmed in a pre-survey (Intraclass Correlation Coefficient was 0.86, $p < 0.01$). We measured ASLR twice and adopted the higher value.

The deterioration of symptoms in the upright position is recognized as typical in LCS. We measured VAS to evaluate the degree of pain. Patients were asked to stand in an upright position (lumbar extension) for 30 s. Immediately afterwards, patients expressed the intensity of subjective pain on a 100 mm line (0 was no pain, 100 was intolerable).

Data were analyzed with PASW Statistics 18.0. First, a simple regression analysis was used to exclude the effect of age on WC or ASLR, and to exclude the effect of BMI on ASLR. When a relationship was not found, the Pearson's correlation coefficient was calcualted to examine the relationship between WC and FFD, ASLR and VAS. A p value < 0.05 was considered statistically significant.

RESULTS

The average of WC was 221.9 ± 162.3 m. The other parameters are presented in Table 1. In simple regression analysis, age did not affect WC ($r^2 = 0.02$, $p>0.05$), and ASLR was not affected by age ($r^2 = 0.04$, $p>0.05$) or BMI ($r^2 = 0.01$, $p>0.05$). According to the Pearson's correlation coefficient, WC was correlated to ASLR ($r = 0.50$, $p<0.01$).

Table 1. The relationship between WC and other parameters

	average ± SD	*r*
FFD (cm)	–2.9 ± 4.3	–0.13
ASLR (kg)	4.9 ± 2.9†	0.50
VAS (mm)	70.5 ± 27.7	–0.20

Each value represents the mean ± SD. † $p<0.01$.

DISCUSSION

In previous studies, it was reported that WC was correlated to vibration sense[19,20], intensity of pain[19], balance ability[20], and body weight[21,22]. In this study, actual WC was correlated with muscle strength in ASLR independent of age or body weight. ASLR is known to be primarily achieved by the rectus femoris (RF)[23] which originates in the anteroinferior iliac spine. Mens et al.[24] conducted a dynamic analysis of pelvic motion during ASLR by X-ray examination. According to their results, the iliac in the elevated leg side rotated forward (pelvic nutation) at the center near the sacroiliac joint, and the iliolumbar ligament on the same side pulled the transverse processes of L4 and L5. As a result, L4 and L5 rotated to the contralateral side (non-elevated leg side). On the basis of this motion analysis, the pelvis would be pulled forward on the elevated side by contraction of RF, and subsequently L4 and L5 might be pulled forward (lumbar extension) and rotated to the opposite side by the tension of the iliolumbar ligament during ASLR. Lordosis and rotation were direction-led by the lumbar spinal canal or intervertebral foramen stenosis[25,26]. Therefore, ASLR strength and WC would be limited by lumbar stenosis induced neurological factors.

Abdominal muscles play an important role during ASLR. Movements of insertions require stabilization of origins in open kinetic chain motion. This stabilization involves activation of muscles originating in the trunk[27]. During ASLR, RF moves from the insertion (tibial tuberosity) to the origin (anteroinferior iliac spine), and at this point the abdominal muscles contribute to stabilization of the pelvis (the origin of RF). If abdominal muscles weaken, the pelvis is rotated forward by reverse contraction (moving from the origin to the insertion) of the RF during ASLR. Thus, abdominal muscles have a role in preventing reverse action of the RF (rotating the pelvis backward) during ASLR. This suggests that patients with LCS may have weak abdominal muscles and that a lack of stabilization in the lower trunk when walking may contribute to the appearance of early IC. However, we could not examine the appearance of neurological deficits during ASLR. It is also possible that patients with LCS have a secondary muscular weakness because they have a narrower range of activity due to IC, and ASLR strength becomes weaker with decreasing range of activity. Further study is needed to establish whether or not the motion of ASLR induces actual neurological deficits.

The averaged FFD value was negative in our patients. The passive SLR test is a useful test for lumbar 4/5 disk herniation. Jonsson and Stromqvist[28] showed that the passive SLR test was commonly used to assess patients with lumbar disk herniation; however, its use was uncommon for LCS. In this study, the averaged FFD was negative. This result suggests that patients with LCS have a wide range of lumbar kyphosis because lumbar flexion makes spinal canal or intervertebral foramen wide, which decreases the stenotic symptoms or signs. Patients with LCS may often retain this posture in daily life; therefore, ASLR is more useful than passive SLR for the evaluation of patients with LCS.

The muscle strength in ASLR was correlated with WC in patients with LCS. This relationship suggests that ASLR leads to lumbar canal stenosis because of lack of stabilization in the lumbar region by the abdominal muscles. We suggest that ASLR is applicable not only to patients with pelvic girdle pain but also LCS.

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