Published in final edited form as:

Arch Phys Med Rehabil. 2012 April ; 93(4): 647–653. doi:10.1016/j.apmr.2011.09.023.

Predictors of Walking Performance and Walking Capacity in People with Lumbar Spinal Stenosis, Low Back Pain and Asymptomatic Controls

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Abstract

Objective—Examine predictors of community walking performance and walking capacity in lumbar spinal stenosis (LSS), compared to individuals with low back pain and asymptomatic controls.

Design—Retrospective analysis.

Setting—University Spine Program.

Participants—126 participants (50 LSS, 44 low back pain and 32 asymptomatic controls), aged 55–80 yrs.

Interventions—Not applicable.

Main Outcome Measure(s)—7-day community walking distance measured by pedometer (walking performance) and a 15 minute walking test (walking capacity). All participants had a lumbosacral MRI, electrodiagnostic testing, and a history and physical examination including history of pain and neurologic symptoms, straight leg raise test, tests for directional symptoms, reflexes, strength, and nerve tension signs. The study questionnaire included demographic information, history of back/leg pain, questions about walking, exercise frequency, and pain level, as well as the standardized Quebec Back Pain Disability Scale.

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Meeting presentation: American Academy of Physical Medicine and Rehabilitation Annual Assembly, Philadelphia, 2005.

More than six authors: The data collection for the original Michigan Spinal Stenosis Study required a large number of co-investigators. The seven authors for this manuscript were those directly involved in conception, data collection, analysis, and manuscript preparation specifically for this manuscript.

Results—BMI, pain, age and female sex predicted walking performance ($r^2 = 0.41$) and walking capacity ($r^2=0.41$). The diagnosis of LSS itself had no clear relationship with either walking variable. Compared to the asymptomatic group, LSS participants had significantly lower values for all walking parameters, with the exception of stride length, while there was no significant difference between the LSS and low back pain groups.

Conclusions—BMI, pain, female sex, and age predict walking performance and capacity in people with LSS, low back pain, and asymptomatic controls. While pain was the strongest predictor of walking capacity, BMI was the strongest predictor of walking performance. Average pain, rather than leg pain was predictive of walking. Obesity and pain are modifiable predictors of walking deficits that could be targets for future intervention studies aimed at increasing walking performance and capacity in both the low back pain and LSS populations.

Keywords

obesity; pain; body mass index (BMI); rehabilitation; disability; neurogenic claudication; ICF

Degenerative lumbar spinal stenosis (LSS) is a debilitating and chronic condition which typically affects adults in their sixth and seventh decades of life.¹ Neurogenic claudication, the cardinal manifestation of LSS is described as a progressive onset of pain and neuromuscular deficit (numbness/tingling/weakness) in the buttocks and lower extremities, initiated by walking.^{2–6} These symptoms of LSS often lead to substantial disability,⁷ where activities requiring walking are often avoided and health related quality of life is diminished.^{8;9} It is clear that walking is critical to overall health, and thus limitation in walking is a serious clinical indicator that should be monitored by patients and their doctors.

Accordingly, there has been a recent emphasis on walking capacity as a key outcome indicator for patients undergoing treatment for LSS.^{10;11} Most recent studies that focused on treatment for LSS reported some measurement of walking capacity.^{12–19} Yet, almost all such studies used self report methods or tests of walking capacity in laboratory settings (e.g. treadmill protocols). Few studies have examined 'community walking' or performance in real life settings, with the exception of a recent study by Schulte et al.¹⁸ which examined step activity monitoring in patients undergoing surgery for LSS, and Winter et al.¹⁹ who looked at daily walking ability in patients with LSS and osteoarthritis.

The International Classification of Functioning, Disability and Health provides a conceptual framework that highlights the difference between capacity and performance.²⁰ This classification system defines *capacity* as an individual's ability to perform a given task or action in a controlled setting, and *performance* as the activities performed by an individual on a day to day basis in the context of their own life (community walking participation). This distinction between capacity and performance may prove to be essential in the study of ambulatory disability caused by LSS. Recent research demonstrates that although they are related, the constructs of walking capacity and walking performance in people with LSS are not the same.²¹ This suggests that an increase in walking capacity does not necessarily imply increased walking performance in the community. It is thought that the functional goal of interventions for LSS is improvement in performance, not capacity. Therefore if we can elucidate factors associated with walking performance in LSS, this may guide appropriate management of limitations in community walking in this population.

The Michigan Spinal Stenosis Study, a prospective masked evaluation of clinical, electrodiagnostic and radiological findings in persons with LSS, back pain and asymptomatic volunteers provides an excellent comparative population to evaluate these issues. Previous publications outline detailed methodology and core results from this

study,^{22–24} however, these reports did not examine the concepts of walking performance and walking capacity, or the predictors of these constructs.

The primary objective of this study was to examine the factors associated with walking performance (community walking participation) and walking capacity in people LSS. In order to determine if the factors associated with walking in LSS are unique, a secondary objective aimed to compare walking parameters and factors associated with walking between the LSS population and those with low back pain and asymptomatic volunteers. We hypothesize that people with LSS ambulate less in the community than both asymptomatic volunteers and persons with low back pain but without spinal stenosis.

Methods

This study was a retrospective analysis of data from the Michigan Spinal Stenosis Study, a prospective trial investigating clinical, electrodiagnostic and radiological findings in persons with LSS, back pain and asymptomatic volunteers. More detailed methodology regarding subject recruitment and data collection can be found in the original publications resulting from this trial,^{22–24} including a flow chart of the original study protocol.²⁴

Ethics approval for involvement of human participants was obtained through the University of Michigan Health IRBMED ethical review board.

Subject recruitment

The following is a synopsis of subject recruitment from the Michigan Spinal Stenosis Study.²² Lumbar MRI reports from the university scanner for persons aged 55 to 80 years were screened to identify potential participants. The age range was selected in order to provide data that is representative of individuals with degenerative lumbar spinal stenosis, who could be considered candidates for surgical intervention. Below the age of 55, the chance of a disc herniation being the primary pathology, as opposed to spinal stenosis, is higher. In people over the age of 80, the rate of co-morbidities is high and the likelihood of surgical intervention for LSS is lower. The goal was to recruit 90 persons with the radiologic diagnosis of lumbar spinal stenosis (regardless of symptoms), 30 persons who had a preliminary diagnosis of non-radiating back pain with no radiologic stenosis, and 30 people from the community with no back pain complaint, who had none of the exclusion criteria, but were within the 55–80 year age range. All participants were recruited by telephone, however prior to any telephone contact, letters were sent with information pertaining to the study. The letters included contact information for study personnel where potential participants could respond to refuse telephone contact. Exclusion criteria included any hospitalization or surgery in the previous 6 months, alcohol consumption > 10 drinks/week, diabetes or other causes for polyneuropathy, inability to walk 5 meters, previous lumbar spine surgery, or contraindications to MRI or electromyography.

Of the 322 potential participants identified and screened by phone, (80 asymptomatic, 100 back pain and 142 stenosis), 150 were subsequently tested. Of the 150 who were tested, 9 were clinically disqualified due to neuromuscular disease or cancer, and 15 were eliminated due to missing key data.²² Therefore, data from a total of 126 participants was included in the present retrospective analysis.

Questionnaire, walking measures and BMI

As the first step in data collection, all participants completed a patient questionnaire, a laboratory walking capacity test, and were instructed regarding completion of the 7 day home pedometer walking performance test.

The patient questionnaire included demographics, history of back/leg pain, questions about the patient's perceived walking distance, exercise frequency, and pain levels (100mm visual analog scales (VAS) for average pain in the past week). Participants were asked "Do you have difficulty ambulating?" and were required to answer yes or no. Participants also completed the standardized Quebec Back Pain Disability Scale to assess pain and disability resulting from back pain.²⁵ Height and weight were measured for each participant.

Self-Paced Walking Test

The validated Self-Paced Walking Test was performed. The Self-Paced Walking Test and its development have been described in detail previously.²⁶ According to the Self-Paced Walking Test protocol, participants walked unassisted, at their own pace around a large rectangular hallway in the clinic until they felt they had to stop due to symptoms of LSS or until a time limit of 15 minutes had been reached. Participants were able to walk continuously in a loop without stopping or turning. The test administrator followed the subject with a distance measurement instrument (Lufkin® Pro-Series Model PSMW38) and a stopwatch to measure time. The primary outcome of this test was completed distance measured in meters. To ensure that the intensity level of the walk was sub-maximal (<85% of age predicted maximum heart rate),²⁷ a heart rate monitor was used and observed during the duration of the walk. Stride length was determined during this test by counting the number of steps taken by participants over a 92 m stretch of the hallway, and then dividing this number into 92m to obtain a value in m/stride. This was repeated three times for each participant and the values were averaged.

7 day home pedometer walking performance test

The pedometer test was performed after conclusion of all other tests. The pedometer used in the study was the Yamax Digi walker (DW SW-701). Output from these devices is measured as distance walked (m) and the number of steps taken. The pedometer was pre-set to the individual participants' weight and calculated stride length. Pedometers were placed laterally on the participant's belt or waist and then positioned to the midline of the thigh. Participants were instructed to wear the pedometer during the waking hours for seven days, and to maintain their current level of activity. Participants were blinded to the pedometer data using black tape placed over the display screen. Participants were instructed regarding how to keep a daily log to indicate exact wear times for the pedometer, and any pedometer malfunctions. Although a number of electronic pedometers are commercially available, Tudor-Locke et al. reported that the Yamax Digiwalker was the most accurate waist-borne instrument evaluated to date. The manufacturers report a 0.3% permissible rate of step miscounting.²⁸

Electromyography

Following the questionnaire and walking test, electrodiagnostic testing was performed by a masked physician using standard techniques described in detail previously,^{22;24} including monopolar needles and temperature adjustment. Testing included sural sensory, peroneal motor, F-wave and H-wave nerve conduction studies, a 5 muscle EMG screen of the most affected or a randomly chosen limb.

Defining participant groups

Following the questionnaire, walking test and electromyography, each participant's case was examined independently by a physiatrist, a neuro-radiologist and a spine specialist surgeon. Each of the three physicians independently assigned each participant to one of the three diagnostic groups (spinal stenosis, back pain, asymptomatic).

Physiatrist exam

For each participant, a physiatrist performed a comprehensive and codified, but unconstrained, spinal history and physical examination after reviewing the questionnaires and the walking test results.²² The physiatrist recorded a clinical impression of spinal stenosis, low back pain or asymptomatic volunteer. A clinical impression of spinal stenosis was based on presence of ambulation difficulty (neurogenic claudication), and other factors including history of pain and neurologic symptoms, location of symptoms, straight leg raise test, femoral nerve test, and results of examinations for directional symptoms (flexion/extension), tenderness over the lumbar or sacral spine, abnormal or absent reflexes, strength deficits and nerve tension signs.

Neuro-radiologist exam

A blinded neuro-radiologist reviewed each patient's non-contrast lumbosacral MRI and categorized them as either having LSS or not. The radiologist did not attempt to categorize participants as asymptomatic or back pain based on the MRI. He or she reviewed images in the axial plane at each spinal level between L1 and S1 and noted if spinal stenosis was present.

Spine surgeon exam

An experienced spine surgeon reviewed the patient history and physical examination records, patient questionnaire and MRI films, but did not physically examine the patients. Based on their review, the surgeon categorized participants into the three groups (spinal stenosis, back pain, asymptomatic).

The final decisions for diagnostic groupings from the physiatrist, radiologist and spine surgeon were examined. A group was then compiled of only those participants who had been given the same diagnosis by all three physicians. This group of participants was considered the gold standard (criterion) population, given that all three physicians agreed on the diagnoses. This criterion standard grouping was used only as a grouping variable during the regression analysis. All main analyses were conducted using the physiatrist impression groupings (n=126).

Data analysis

Descriptive statistics were used to describe the study sample. One-way analysis of variance was used for comparison between the three groups, with Tukey honestly significant difference comparisons conducted post-hoc to identify significant between-group differences. Chi-square tests were used to compare groups for categorical variables. Stepwise multivariable linear regression models were developed to determine which factors were most highly associated with walking performance and walking capacity. SPSS version 17.0 (Chicago, IL) was used for analysis of data. A significance level of $p < 0.05$ was set for all analyses, with the exception of univariate regression analysis $p < 0.20$ was considered significant.

Pedometer data

Pedometer log books were inspected for each participant. If it was recorded that the pedometer was not worn on a given day, or that it was only worn for a partial day, the data for that day was excluded. Pedometer data were inspected, and a minimum 5 days of complete data were required for each individual. All participants met this requirement. There were no pedometer malfunctions.

Univariate analysis

The two dependent variables examined were total walking distance measured over the 7 day pedometer test (walking performance in kilometres) and total walking distance measured in the 15 minute walking test (walking capacity in metres). Univariate linear associations were examined for six domains, including MRI parameters (anterior-posterior canal diameter, anterior-posterior dural sac diameter, dural sac area, presence of stenosis at each level), demographics (age, BMI, sex), pain (presence of pain below the knee, worst VAS pain, average VAS pain, pain related function variables from the Quebec Disability Scale), self-reported walking and exercise variables (reported walking difficulty, perceived walking distance, and exercise frequency), physical examination findings (presence of neurologic symptoms, leg pain with straight leg raise test, leg pain with femoral nerve test, tenderness over the lumbar or sacral spine, presence of directional symptoms in flexion or extension, reflex deficit, strength deficit, nerve tension signs), and EMG (presence of abnormal findings from sural sensory, peroneal motor, F-wave and H-wave nerve conduction studies, presence of fibrillations or polyphasic motor units from the 5 muscle EMG screen). Pearson Product Moment correlation coefficients were used to examine univariate associations. Independent variables associated with either dependent variable at $p < 0.20$ were retained for multi-variable modeling.

Multivariable Modeling

For each dependent variable, a regression model was developed for each of the six domains of independent variables. For each domain model, significant correlates at P-values 0.1 or less were retained for a final model. A stepwise forward variable selection technique was then employed for the final models. A significance value of 0.05 was set for inclusion in the final model. Finally, general linear modeling was employed to determine whether the influence of predictors on each of the dependent variables varied by group. Both the physiatrist and criterion standard diagnoses were used as grouping variables. The criterion standard grouping, (used only as a predictor in regression analysis) was made up of 24 people with LSS, 12 with back pain and 12 asymptomatic controls.

Results

Data were analyzed for 126 participants. The final groupings, based on the physiatrist impression included 50 people with LSS, 44 people with low back pain but no LSS and 32 asymptomatic participants. Study sample characteristics are described in Table 1. A one-way ANOVA was used to test for differences among the three groups. Overall, there were very few significant differences between the groups. The back pain group was significantly younger than the stenosis group. Both the stenosis and back pain groups had significantly higher pain and Quebec Disability Scale scores compared to the asymptomatic group.

The walking parameters are presented in Table 2. Compared to the asymptomatic group, the LSS group had significantly lower values for all walking parameters, with the exception of stride length. There was no significant difference between the LSS and back pain groups for any of walking measures. There was no difference in self-reported difficulty ambulating between LSS and back pain groups. According to a set of evidence-based steps/day indices proposed by Tudor-Locke et al,²⁹ both the asymptomatic and low back pain groups fall in the 'low active' range while the LSS group falls in the 'sedentary' range for steps per day (Table 2).

Predictors of walking performance

Results of the regression analyses are presented in Table 3. Variables retained from univariate analyses ($p < 0.1$) for walking performance (7-day pedometer distance) included age,

sex, BMI, presence of an abnormality during the physical examination, average pain during the past week, smallest area of the dural sac, presence of stenosis at L4–5, presence of stenosis at L5–S1, smallest anterior-posterior canal diameter and smallest anterior-posterior thecal sac diameter. The final model for walking performance included BMI, average pain over the past week (VAS), age and sex ($r^2 = 0.41$), with BMI as the strongest predictor.

Predictors of walking capacity

Variables retained from uni-variate analysis ($P < 0.1$) for walking capacity (walking test distance) included age, sex, BMI, presence of an abnormality during physical examination, self-reported walking difficulty, frequency of exercise, average pain during the past week, ability to walk up stairs, ability to run 2 miles, smallest area of the dural sac, presence of stenosis at L4–5, presence of stenosis at L5–S1, smallest anterior-posterior canal diameter, smallest anterior-posterior thecal sac diameter, presence of a nerve conduction abnormality, absent H-wave, and presence of any abnormality during electrodiagnostic testing. The final model for walking capacity included average pain over the past week, BMI, age and sex ($r^2 = 0.41$), with average pain over the last week as the strongest predictor.

Neither the physiatrist diagnosis grouping variable nor the criterion standard diagnosis grouping variable predicted walking performance or walking capacity. Further, no interactions were identified using general linear modeling between the grouping variables and any of the predictors. This means that the degree to which the independent variables predict walking performance and capacity did not vary by diagnosis.

To ensure that the analysis was adequately powered, a post-hoc power analysis for multiple regression was conducted. With an alpha level of 0.05, including a maximum of 16 predictors in the model and an observed r^2 of 0.41, the observed power was 0.99.

Discussion

The factors found to predict walking performance and capacity in the present study were obesity (BMI), pain, age and female sex. Interestingly, the effect of these predictors was not influenced by diagnosis or 'grouping'. Diagnosis by a physiatrist was not a predictor of either walking variable, nor was diagnosis based on stringent criteria of consensus between physiatrist, neuroradiologist and spine surgeon. Therefore, the presence or absence of LSS as a diagnosis had no unique effect on walking. This implies that people who have the same level of pain, whether from LSS or mechanical back pain will have similar walking limitations. This also implies that persons who have the same BMI will have similar walking limitations, regardless of diagnosis. These results have important implications for management of LSS given that BMI and pain are modifiable. Efforts should be made to investigate interventions aimed at these factors. Because obesity and pain as predictors of walking are not unique to LSS, methods used to increase walking in other population groups (e.g. low back pain) could be considered for people with LSS.

Body Mass Index

One of the most important findings from this study is that higher BMI predicted lower community walking participation and capacity, independent of diagnosis. While pain was the strongest predictor of walking capacity, BMI was the strongest predictor of community walking. This implies that while pain limits what you *can* do in a testing environment, BMI limits what you *actually* do in your day to day life. We have previously shown that obese people walk less than people who are not obese.³⁰ BMI is likely to be higher in populations that ambulate less and may be a marker for general de-conditioning. Owing to their age and symptoms, people with may potentially have serious problems keeping their weight under

control. It is possible that interventions aimed at decreasing BMI in people with LSS may have a substantial impact on ambulatory behavior. Weight loss may decrease the deforming forces on the spine while at the same time decreasing the work associated with walking. No studies to date have addressed the possibility of increasing walking in people with LSS through weight loss.

Pain

Average pain was found to be the most significant predictor of walking capacity and a strong predictor of walking performance. The relationship between pain and walking is well known. Iversen et al.³¹ reported a negative correlation between pain and self-reported walking distance in LSS and asymptomatic populations, while Yamakawa et al.³⁰ found that pain severity had a significant inverse relationship with walking in patients with low back pain and asymptomatic controls. In a recent study, the factor found to be most highly associated with walking capacity in LSS was presence of leg pain immediately following walking.³² However, presence of leg pain was not found to be a predictor of walking capacity or performance in the present study. This lack of relationship between leg pain and walking could be a result of the timing of pain measurement. In the study by Tomkins et al.³² only post-walking leg pain predicted capacity, not average pain or pre-walking pain. Future studies investigating walking in LSS could consider including participants with more severe symptoms, and measurement of pain during, and immediately following walking. Such study designs might be more likely to find a stronger relationship between leg pain and walking. However, results from the present study suggest that a more global perception of pain (rather than leg specific) is predictive of walking.

Pain reduction is already one of the primary goals for treatment in LSS, traditionally focusing on patho-physiology with injections and surgery. However, it is possible that other options for pain management could be effective, including medications, physical therapy, as well as addressing fear of movement (kinesiophobia) and fear of pain through patient education or multidisciplinary rehabilitation efforts.

Age

It is not surprising that age was found to be such a strong predictor of walking parameters in all of the groups. Physical activity and walking in general tend to decrease with age. Factors that relate to decreased walking in the elderly include muscle atrophy, decreased stride length and declining motor speed, as well as obesity, socioeconomic status and education level.^{33–36} Mahart et al.³⁶ demonstrated that 60% of older adults get no exercise and that speed of walking declines by 1.6% per year as we age. People with LSS may be at particularly high risk for decreases in walking owing to their age and to their symptoms.³⁷ However, the results of our study suggest that age, more than the diagnosis of LSS predicts limited walking. This could be because age affects walking through other factors including lack of necessity of walking, age-related inactivity, lack of accessibility to exercise facilities, fear of falling and co-morbid health conditions. Therefore, while age is not reversible, it may be a marker for yet-unproven reversible aspects of disability such as contracture, decreased strength, balance deficits, decreased social demands and sedentary behavior.

Exercise frequency

While exercise frequency was found to be a correlate of walking capacity in uni-variate analysis, it was not one of the strongest predictors of either walking variable in the final model. This suggests that in these participants, volume of physical activity (performance) may not be dependent on frequency of formalized exercise sessions, but on cumulative walking behaviour throughout the day.

Comparison between groups

As anticipated, the LSS group demonstrated significantly lower community walking performance and walking capacity compared to the asymptomatic group. These results are consistent with previous literature suggesting significant walking limitations in LSS patients compared to asymptomatic individuals.^{3;8;38} Although all of the walking outcomes were lower in the LSS group compared to the low back pain group, the differences were not significant. This is the first study examining walking performance in both LSS and low back pain, and suggests that walking limitations in the two groups are similar. This is surprising considering that while some studies have reported walking to be limited in low back pain,^{39;40} ambulatory limitation (neurogenic claudication) is considered to be a hallmark of LSS. It is possible that testing participants with more severe LSS and neurogenic claudication may yield different results. The present results do suggest that given the similar limitations between the groups, interventions aimed at increasing function in low back pain may apply to the LSS population.

Study Limitations

The strengths of this study include the use of an objective walking test to assess walking capacity and an objective measure of community performance (pedometer). The reliability of community walking data may also have been strengthened by the extended period of time (7 days) over which the participants were instructed to wear the pedometer. One limitation of the study was that there were few patients in the LSS and low back pain groups with severe symptoms. Results may have differed if the sample was comprised of participants with more severe symptoms. However, the prospective design, relatively large and clinically diverse population, substantial clinical testing and use of diagnostic measures in keeping with current standard of practice are all attributes that strengthen the conclusions.

Pedometer data were collected over the period of two years, so it is possible that seasonal variations in walking were present. However, the seasonal effect would be similar across groups as participants from all three groups were recruited and tested at varying times throughout the 2 year period. It is also possible that occupation could play a confounding role in explaining the variance in 7-day walking performance, given that participants may have walked more or less based on the nature of their daily occupations. Unfortunately we did not have information regarding participant occupations, so could not examine this.

Lastly, although pedometers as used in this study have been shown to be an accurate means of measuring community walking, activity monitors (accelerometers) used in our ongoing research provide even more valuable data (activity counts, intensity) which could be used to assess effectiveness of clinical interventions.

Conclusion

This is the first study of which we are aware examining factors associated with walking performance in the community in people with LSS. Results suggest that walking disability is related to obesity, pain, age and female sex, independent of diagnosis. While average pain was found to be the strongest predictor of walking capacity, BMI was the strongest predictor of community walking participation. This suggests that while pain limits what people can do in a testing situation, BMI limits what people are doing in their day to day lives. Leg pain was not found to be a predictor of walking, while average pain was, suggesting that a more global perception of pain is associated with walking function. These results have implications for clinical management of LSS and low back pain, given that both pain and BMI are modifiable. Research is warranted to examine whether novel treatments aimed at

pain and obesity could result in improvements in both walking capacity and community walking performance.

Acknowledgments

Support: This is a publication of the Spine Program of the University of Michigan which is funded by the United States Department of Health and Human Services, National Institutes of Health under Grant #5 R01 NS41855-02. The opinions contained in this publication are those of the grantee and do not necessarily reflect those of the United States Department of Health and Human Services. We certify that no party having a direct interest in the results of the research supporting this article has or will confer a benefit on us or on any organization with which we are associated AND, if applicable, we certify that all financial and material support for this research (eg, NIH or NHS grants) and work are clearly identified in the title page of the manuscript.

Abbreviations

LSS	Lumbar Spinal Stenosis
BMI	Body Mass Index
MRI	Magnetic Resonance Imaging
VAS	Visual Analog Scale for Pain

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Table 1

Clinical Characteristics of Study Group (n=126)

Clinical characteristics	All subjects n=126	Asymptom. n=32	Back pain n=44	Stenosis n=50	Statistics (F or X ²)	P-value
Age Mean (SD)	65.32 (7.62)	66.19 (8.01)	62.27 (6.70)	67.41 (7.41) *	F=6.469	0.002
BMI ¹ Mean (SD)	27.64 (5.60)	27.80 (5.51)	27.62 (6.51)	27.57 (4.88)	F=0.197	0.822
Pain ² Mean (SD)	3.11 (2.70)	0.17 (0.49)	3.79 (2.43) +	4.32 (2.38) +	F=39.835	0.000
Quebec ³	28.17 (2.70)	3.42 (7.69)	37.16 (20.68) +	35.60 (20.96) +	F=40.152	0.000
Sex % (n) female	66.7% (84)	65.5% (21)	72.7% (32)	62.0% (31)	X ² =1.23	0.54
Exercise % of column (n)					F= 1.671	0.192
never	7.2% (9)	3.2% (1)	6.8 % (3)	10.0% (5)		
seldom	19.2% (24)	12.9% (4)	25% (11)	18.0% (9)		
1-2X/wk	16.0 % (20)	19.4% (6)	27.3% (12)	4.0 % (2)		
3+X/wk	57.6% (72)	64.5% (20)	40.9% (18)	68.0% (34)		

¹ BMI = Body Mass Index (kg/m²)

² Pain = average pain in the previous week on a 0-10 visual analog pain scale

³ Quebec Back Pain Disability Scale Total (Sum of 20 items)

* Significantly different from Back Pain

+ Significantly different from Asymptomatic

Table 2

Comparison of key walking parameters between groups (n=126)

	Asymptomatic (n=32) Mean $\pm$ SD (95% CI)	Back pain (n=44) Mean $\pm$ SD (95% CI)	Stenosis (n=50) Mean $\pm$ SD (95% CI)	Statistic (F or χ^2)	P value
7 day pedometer distance (km)	34.55 $\pm$ 21.3 (26.9 – 42.2)	31.17 $\pm$ 21.5 (24.57 – 37.78)	22.62 $\pm$ 17.29 ⁺ (17.71 – 27.53)	F = 4.070	0.019
Mean daily step count from 7 day pedometer test (steps)	6405 $\pm$ 3502 (5142 – 7668)	5771 $\pm$ 3479 (4701 – 6842)	4386 (3188) ⁺ (3480 – 5292)	F = 3.942	0.002
15 minute walk distance (m)	1096 $\pm$ 209 (1021 – 1171)	988 $\pm$ 265 (908 – 1069)	875 (307) ⁺ (789 – 963)	F = 6.612	0.002
15 minute walking velocity (km/hr)	4.37 $\pm$ 0.83 (4.07 – 4.67)	4.10 $\pm$ 0.83 (3.84 – 4.35)	3.76 (0.90) ⁺ (3.50 – 4.01)	F = 5.125	0.007
Stride length (m/stride)	0.79 $\pm$ 0.12 (0.75 – 0.83)	0.80 $\pm$ 0.15 (0.75 – 0.84)	0.75 (0.14) (0.71 – 0.79)	F = 1.234	0.295
Difficulty Ambulating (% yes)	0 (0.0%)	20 (45.5%) ⁺	33 (64.7%) ⁺	χ^2 = 11.00	0.004

⁺ Significantly different from Asymptomatic

Table 3

Predictors of walking performance and walking capacity (n=126)

Dependent variable	Walking Performance: 7-day pedometer distance (km) ($r^2 = 0.41$)			Walking Capacity: Walking distance (m) ($r^2 = 0.41$)		
	Unstandardized Coefficient	B	Standard Error	Unstandardized Coefficient	B	Standard Error
BMI ¹	-1.47 ***	-0.390	0.292	-14.03 ***	-0.305	3.59
Pain ²	-2.44 ***	-0.328	0.582	-36.94 ***	-0.402	7.16
Age (years)	-0.816 ***	-0.303	0.208	-10.55 ***	-0.317	2.55
Female gender	-7.10 *	-0.166	3.31	-87.37 *	-0.166	40.70

¹ BMI = Body Mass Index (kg/m²)

² Pain = average pain in the previous week on a 0–10 visual analog pain scale.

* p<0.05

*** p<0.0001