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Lumbopelvic Pain and Threats to Walking Ability in Well-Functioning Older Adults: Findings from the BLSA

Eleanor M. Simonsick, PhD^{1,2}, Benjamin Aronson, BA³, Jennifer A. Schrack, PhD⁴, Gregory E. Hicks, PhD⁵, Gerald J. Jerome, PhD⁶, Kushang V. Patel, PhD⁷, Stephanie A. Studenski, MD, MPH¹, and Luigi Ferrucci, MD, PhD^{1,2}

¹Intramural Research Program, National Institute on Aging, Baltimore, MD

²Johns Hopkins University School of Medicine, Baltimore, MD

³George Washington University, Washington, DC

⁴Department of Epidemiology, Johns Hopkins University Bloomberg School of Public Health, Baltimore, MD

⁵Department of Physical Therapy, University of Delaware, Newark, DE

⁶Department of Kinesiology, Towson University, Towson, MD

⁷Department of Anesthesiology and Pain Medicine, University of Washington, Seattle, WA

Abstract

OBJECTIVES—To examine the potential contribution of lumbopelvic pain (LPP) severity in well-functioning older adults to poorer walking efficiency and endurance and gait speed and decline in these mobility parameters over one to five years.

DESIGN—Longitudinal analysis of Baltimore Longitudinal Study of Aging data

SETTING—National Institute on Aging, Clinical Research Unit, Baltimore, MD

PARTICIPANTS—Well-functioning men and women aged 60 to 89 years (n=878).

MEASUREMENTS—Interviewer-administered questionnaire ascertained reported presence and severity of back and/or hip pain in the preceding 12 months and reported walking ability including ease of walking one mile. Certified examiners assessed usual gait speed, the energetic cost of walking (VO₂mL/kg/m) and time to walk 400m as quickly as possible. Covariates included sex, age, age-squared, race, height, weight, exercise and smoking.

RESULTS—Overall, 31.4% had mild and 15.7% had moderate to severe LPP. In adjusted analyses, reported walking ability, endurance walk performance and energetic cost of walking were worse with increasing LPP severity (p<.001, p=.007, p=.049, respectively). Usual gait speed did not vary by LPP (p=.31). Longitudinally, over an average 2.3 years, persons with new or sustained LPP had worse follow-up level, greater mean decline and higher likelihood of

Corresponding author: Eleanor M. Simonsick, PhD, 3001 S. Hanover St, 5th Floor, Baltimore, Maryland 21224, 410-350-3965, simonsickel@mail.nih.gov.

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meaningful decline in reported walking ability than persons free of LPP or whose LPP resolved. Walking performance did not differ by LPP follow-up status.

CONCLUSION—LPP was common in well-functioning older adults and concurrently associated with greater energetic cost of walking and poorer perceived and observed walking endurance. The longitudinal impact of LPP remains unclear, but worsening perception of walking ability and its contribution to future mobility loss warrants further attention.

Keywords

back pain; energetic cost; walking endurance; reported walking ability

INTRODUCTION

Pain in the lower back affects from one to two-thirds of older adults in a given year.^{1–5} Over the past 15 years a wealth of research has revealed the functional consequences of back pain; 1–3, 6–9 yet, important gaps remain with respect to well-functioning older adults; that is, persons with no walking limitations and whether back pain may serve as a catalyst for mobility decline through its potential contribution to poorer walking efficiency and related manifestations including compromised walking endurance, slower gait speed and steeper decline in mobility parameters over time.¹⁰

Most investigations of back pain in older adults have examined more general populations in which mobility limitations are highly prevalent^{11,12} and/or focused on lower order tasks and abilities^{12,13} which may be insensitive indicators of mobility deficits in well-functioning older adults.^{3,8,14,15} The scant research on back pain and energetic efficiency has used small samples and has been largely inconclusive.¹⁶ Additionally, persons reporting back pain often have low physical activity^{17,18} raising the possibility that back pain's impact on mobility may be underappreciated as low activity may obscure the consequences of intermittent and/or lingering back pain. Lastly, pain severity¹⁹ and persistence over time²⁰ have been largely overlooked with respect to mobility decline.

This study examines the relationship between lumbopelvic pain (LPP) operationalized as reported back and/or hip pain within the preceding year and mobility assessed as usual gait speed, endurance walk performance, energetic cost of walking and reported walking ability in well-functioning persons aged 60 to 89 years participating in the Baltimore Longitudinal Study of Aging (BLSA). Since LPP is frequently chronic²¹ and recurrent,²² this study also investigates the association between LPP follow-up status and mobility change one to five years later.

METHODS

Study Population

The study population consists of 878 well-functioning men and women (50.8%) aged 60 to 89 years participating in the BLSA who reported on pain in the back, hips and knees over the past year, met eligibility for endurance walk testing (i.e., no major contraindications for fitness testing or exacerbation of cardiac symptoms in the preceding 3 months), completed a

400m walk as quickly as possible and had a measure of the energetic cost of walking (see below). The first visit in which all criteria were met was termed the index visit.

The longitudinal sample consists of 667 participants who had at least one follow-up visit within one to five years of their index visit (mean=2.3 years) in which both LPP and usual gait speed were assessed. Those without an eligible follow-up were not due or overdue for a visit (n=101), were seen outside of five years (n=18), had a phone interview only (n=15) or were missing back pain status (n=4). Twenty-two had died, 15 developed dementia or became incapacitated, 3 withdrew and 33 were lost to follow-up. Participants without an eligible follow-up were younger (70.4 vs. 72.1 years; $p=.007$) and had a lower energetic cost of walking (.156 vs. .165 $\text{VO}_2\text{ml/kg/m}$; $p<.001$), but did not differ on any other key characteristic. An additional 161 participants were unavailable for longitudinal analyses on the energetic cost of walking due to missing data – 30 did not qualify for testing and 131 had no oxygen consumption assessed due to equipment servicing. All visits occurred between April 2007 and March 2017.

The BLSA began in 1958 as a continuous enrollment cohort study of normative aging with eligibility restricted to persons free of cognitive impairment, functional limitations, chronic diseases and cancer within the past 10 years. Once enrolled, participants are followed until death through comprehensive health, cognitive and functional evaluations conducted during a three-day visit to the National Institute on Aging Clinical Research Unit in Baltimore, Maryland. Visits occur biannually for persons aged 60 to 79 years and annually for persons aged 80 and older. The BLSA protocol was approved by the National Institute of Environmental Health Sciences Internal Review Board and participants provided informed consent at all visits.

Measures

Lumbopelvic Pain—Presence and severity of lumbopelvic pain (LPP) was determined from interviewer-administered questions: In the past year, have you had any back pain? Participants responding “yes” were asked to “Please rate your usual back pain over the past year from 0 to 10.” Persons denying pain or endorsing a level of “0” were coded as having no back pain (0). Those endorsing a pain level from 1 to 5 were considered to have “mild” pain (1) and those endorsing 6 or above were coded as having moderate to severe pain (2). Persons ever having hip pain were asked, “In the past 12 months have you had hip pain lasting at least one month?” Those responding “yes” were asked for each affected hip the usual pain severity in the past 12 months – mild, moderate, severe or extreme. Those reporting no pain were coded 0, those with mild pain were coded 1 and those with moderate or worse pain were coded 2. If pain was reported for both hips, severity was the highest pain level endorsed for either hip. LPP score represents the sum of back and hip pain which can range from 0 to 4, but was truncated at 2 because scores of 3 and 4 were rare; 2.5 and 1.6%, respectively, yielding three pain levels: 0=none, 1=mild, 2=moderate to severe.

The same approach categorized LPP at follow-up. For the longitudinal analyses, LPP status at the index and follow-up visits were compared yielding four categorizations. Participants with no pain at both visits were labeled absent, those with any pain at the index visit but not at follow-up were labeled resolved, those free of pain at the index visit but reporting pain at

follow-up were labeled new onset and those with pain at both visits were labeled persistent. As LPP that developed or resolved between visits was not captured, it is best to consider these categories as gross summaries of LPP status over time.

Knee Pain—Since pain typically co-occurs in multiple locations in older adults² and knee pain has been associated with higher energetic costs of walking,²³ we included knee pain as a covariate in separate analyses. Participants reporting ever having knee pain were asked if they had knee pain lasting at least one month within the last 12 months and the pain level in the affected knees within the past 30 days while walking on a flat surface. Those reporting no pain were coded 0, those endorsing mild pain were coded 1 and those experiencing moderate or worse pain were coded 2.

Reported Walking Ability—Perceived walking ability was determined from the following questions: Because of a health or physical problem, do you have any difficulty walking a quarter of a mile that is about 2 or 3 blocks, without stopping? Those reporting difficulty were asked whether they had a little, some or a lot of difficulty or were unable to walk. Persons denying difficulty were asked how easy it is for them to walk a quarter of a mile – very, somewhat, or not so easy – followed by whether they have any difficulty walking one mile and the ease of walking one mile if no difficulty was reported. Responses were combined to create a walking ability index ranging from 0 to 9, where 0 represents unable to walk ¼ mile and 9 indicates walking one mile is very easy.²⁴ Meaningful decline at follow-up was defined as a loss of one point.^{24,25}

Usual Gait Speed—Usual gait speed was assessed over 6 meters with participants asked to walk at their “usual walking pace” for two trials. Total time recorded to the hundredth of a second was divided into 6 to obtain usual gait speed in meters per second. The fastest trial was used in the analyses. Meaningful decline was defined as a loss of .05m/s per year.^{25,26}

Endurance Walk Performance—Endurance walk performance derives from the Long Distance Corridor Walk (LDCW), a two-stage, endurance walk test performed over a 20-meter course²⁷ in a tiled corridor. The first stage consists of a 2.5 minute usual pace walk followed immediately by a 400m walk “done as quickly as possible.” Seconds to complete the 400m walk was the measure of endurance walk performance. Meaningful decline was defined as a gain of 12 seconds per year or test failure.^{26,28}

Energetic Cost of Walking—The energetic cost of walking was assessed using indirect calorimetry (Cosmed k4b², Cosmed, Rome, Italy) during the 2.5 minute usual pace walk component of the LDCW.¹⁰ The unit of measurement is the volume of oxygen consumed per kilogram of body weight per meter walked (VO₂mL/kg/meter) calculated as follows: (i) readings from the first 1.5 minutes of testing were discarded to account for workload adjustment, (ii) remaining readings were averaged to derive the average VO₂mL/kg/minute expended during usual walking and (iii) this average value was multiplied by 2.5 (total walk time) and divided by the distance covered in meters. An increase of .006 VO₂mL/kg/meter per year was used to signify meaningful decline which is analogous to a loss of .05 m/s per year for usual gait speed.²⁹

Covariates—Covariates include age, age-squared to account for accelerated slowing with age, self-designated black or non-black race, physical activity and smoking status (current or quit within 10 years versus never or quit over 10 years ago). Physical activity was categorized as sedentary, low, moderate or high based on reported frequency and duration of vigorous and moderate physical activity including brisk walking. Measured height and weight were also accounted for in the analyses.

Statistical Analyses

In the cross-sectional analyses, mean values of the mobility measures – reported walking ability, usual gait speed, 400m time and energetic cost of walking – were compared across categories of LPP designated as *none*, *mild* or *moderate to severe* using separate general linear models adjusted for age, age-squared, sex, race, height and weight, smoking and activity level. A second set of separate models included knee pain.

To examine the longitudinal association between LPP and mobility, LPP status at the index and follow-up visits were compared to yield four categories – absent, resolved, new onset and persistent (see above). Follow-up mobility was examined using: (1) raw follow-up value, (2) change between index and follow-up visits and (3) percent experiencing meaningful decline. Separate general linear models adjusted for age, age-squared, sex, race, height, weight, smoking, activity level and length of follow-up were used to examine differences between the LPP follow-up categories and each mobility outcome. The index value was included in models examining change and percent experiencing meaningful decline. All analyses were performed using SAS, version 9.3 (SAS Institute, Inc., Cary, NC).

RESULTS

Cross-Sectional

Table 1 illustrates the joint prevalence and severity of back and hip pain at the index visit. Back pain was common, affecting 47%; whereas, hip pain occurred in only 8%, the large majority of whom (76%) also reported back pain. Only 16 persons (< 2%) reported hip pain alone. Among those with back pain, 22% reported moderate to severe pain; whereas, among those with hip pain, nearly 70% reported moderate or greater severity. Table 2 compares population characteristics across LPP categories where 52.9% had no LPP, 31.4% had mild and 15.7% had moderate to severe LPP. The study population averaged 71.7 years in age, 50.8% were women and 24.0% were black. In this well- functioning population, less than 4% had smoked within the previous 10 years and over 40% met physical activity recommendations. Those with LPP were also more likely to be sedentary, of black race and report knee pain in the past year.

Adjusted cross-sectional associations between LPP and mobility are depicted in Figure 1. Reported walking ability was worse with increasing LPP severity ($p<.001$), with the moderate to severe group having poorer walking ability than either those with no or mild LPP ($p<.001$ for both). Differences between those with no pain and those with mild pain did not attain statistical significance ($p=.10$). Usual gait speed did not vary by LPP status ($p=.31$). Endurance walk performance was worse with increasing LPP ($p=.007$), but only those

with moderate to severe pain needed more time to walk 400m than either those with mild or no pain ($p=.002$ and $p=.005$, respectively). Energetic cost of walking was slightly higher with increasing LPP ($p=.049$). Participants with any pain and those with moderate to severe LPP had higher costs than those with no pain ($p<.03$ for both).

Accounting for knee pain in the past year did not materially impact the findings with the exception of the energetic cost of walking. Those with any versus those with no LPP still exhibited poorer walking efficiency ($p=.04$), but the moderate to severe group alone was no less efficient than those with no LPP ($p=.10$).

Longitudinal

In the longitudinal sample, 37.9% were free of LPP at both visits, 14.1% no longer reported LPP, 13.8% had new LPP and 34.2% reported LPP at both visits. As shown in Table 3, persons with persistent LPP had lower mean reported walking ability than those in the absent or resolved groups, as well as a greater mean decline and higher percentage with meaningful decline in walking ability. Participants with new onset LPP had greater mean decline and higher percent meaningful decline than persons in the resolved group. No differences emerged between follow-up LPP status and usual gait speed, 400m time or energetic cost of walking.

DISCUSSION

In a well-functioning population aged 60 to 89 years, LPP commonly occurred with over 47% reporting pain within the preceding year and over 62% having LPP at either their index or follow-up visit of whom two-fifths had moderate to severe pain. These rates are higher than found in some studies of older adults,¹⁻³ but comparable to those found in others^{4,5} which may reflect differences in pain assessment and participant characteristics. Although hip pain was included in the definition used here, hip pain alone accounted for less than 2% of LPP cases. The population examined here is not only well-functioning, but also highly active with over 40% spending at least 150 minutes per week in exercise-related activities in contrast to about 3% of the general population of older adults.³⁰ The higher activity levels may explain the high rates of LPP, but whether greater activity contributes to LPP or increases awareness of existing LPP cannot be distinguished. Nevertheless, this observation that LPP prevalence is high in a highly active population supports the concern noted previously that inactivity may obscure prevalent back pain and further that the impact of back pain on walking endurance may be underappreciated.

Contemporaneous pain severity was associated with both reported and observed endurance-related walking including energetic cost but not usual gait speed over a short distance. This suggests that in well-functioning older adults, simple gait speed is an insensitive marker of LPP related debility and more importantly that LPP may initiate early stage mobility loss which first emerges as diminished endurance capacity and greater energetic costs of walking.^{29,31} Absence of any impact of knee pain on the observed associations between LPP severity and mobility may reflect that knee pain was rare ($<4\%$) in those with no LPP in comparison to 15% in those with moderate to severe LPP and that the relationship with mobility was largely driven by LPP severity.

Notably, the only associations between LPP status over time involved reported walking ability with persons with new or persistent LPP reporting lower ability levels at follow-up and experiencing greater decline between visits than persons with no or resolved LPP. The differences were statistically robust in contrast to endurance walk performance and energetic cost of walking which showed no inkling of difference. Typically, performance-based measures are considered more sensitive than self-report,³¹ but perhaps the target distance of one mile for the self-report assessment versus 400 meters and 2.5 minutes for energetic cost of walking renders self-report the more sensitive early marker. Alternatively, LPP may be perceived as making walking less easy even with no evident decline in maximum speed or energetic efficiency in a testing situation. Importantly, when participants report moderate to severe pain of any type at their pre-visit screen, they are encouraged to reschedule for a later date. Thus, self-report may more accurately capture perceived walking ability in the presence of intermittent and/or recurrent LPP; whereas, performance tests conducted in a research setting may underestimate the functional impact of LPP.

Nevertheless, the lack of association between LPP over time and worsening endurance walk performance and energetic cost was unanticipated given evidence of a cumulative and/or long-term negative impact of LPP on mobility,^{19,20} especially in light of the observed decline in reported walking ability. Conceivably, the potential implications of reduced perceived walking ability for walking endurance and efficiency may depend on how individuals respond to diminished ease of walking and even then the consequences of any activity restriction for sustained mobility decline may not emerge until much later.

This study has limitations typical of cohort-based investigations of pain and its manifestations most notably that persons in acute pain were encouraged to postpone their clinic visit and the lack of interim pain assessment between clinic visits which tend to obscure prevalence, severity and recurrence of LPP. Nevertheless, the observed point prevalence of 47% of which one-third complained of moderate to severe pain was greater than typically observed.¹⁻³ Additionally, due to insufficient power, the longitudinal analyses did not differentiate pain severity which may have diminished the ability to observe an association between LPP follow-up status and walking performance especially since the moderate to severe group showed the worse walking initially. This is supported in part by examining the 100 participants who developed (n=27), progressed to (n=33) or had sustained moderate to severe LPP (n=40) at follow-up. This subgroup expectedly had a lower level of and greater decline and a higher proportion with meaningful decline in reported walking ability than all other follow-up LPP status groups and also experienced a higher rate of meaningful decline in 400m walk performance (33.6% vs. 23.9%; p=.048) than persons with no LPP at either visit.

In summary, LPP in well-functioning older adults is associated with higher energetic cost of walking and poorer reported and observed endurance walking ability. Aside from a reduction in reported walking ability, the longer-term consequences of LPP are unclear and may depend on how individuals and their providers respond to and manage their back pain. Future work should address the potential functional benefits of early identification of LPP and response to restorative treatment strategies.

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Author Contributions: Dr. Simonsick had full access to all of the data and takes full responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Simonsick and Aronson. *Acquisition of data:* Simonsick, Schrack, Hicks, Studenski and Ferrucci. *Analysis and interpretation of data:* Simonsick, Aronson, Jerome, Patel and Ferrucci. *Drafting of the manuscript:* Simonsick. *Critical revision of the manuscript for important intellectual content:* Simonsick, Schrack, Hicks, Jerome, Patel, Studenski and Ferrucci. *Statistical analysis:* Simonsick and Aronson. *Obtained Funding:* Ferrucci. *Administrative, technical and material support:* Simonsick, Schrack, Hicks and Ferrucci.

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Impact Statement

We certify that this work is novel in that it examines lumbopelvic pain (LPP) in well-functioning older adults and its potential role as a catalyst for initiating mobility limitation. This study investigates the association between LPP and the energetic cost of walking and related manifestations including perceived and observed walking ability and endurance. As older adults live longer and healthier active lives, attention to conditions that may precipitate threats to independent functioning becomes increasingly important.

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Figure 1.

Mean values by LPP level where 0=none, 1=mild and 2=moderate to severe adjusted for age, age-squared, sex, race, height, weight, smoking and activity level. For **reported walking ability**, the p-value is $< .001$ for trend and .10 for mild versus no pain. For **usual gait speed**, the p-values are .31 for trend, .17 for severe versus no pain, .81 for mild versus no pain and .14 for severe versus mild pain. For **fast 400m walk**, the p-value for trend is .007 and .92 for mild versus no pain. For **energetic cost of walking**, the p-value for trend is .049, .02 for any versus no pain and .43 for severe versus mild pain.

Table 1

Index Visit Prevalence and Severity of Back, Hip and Lumbopelvic Pain in 878 Well-functioning Men and Women Aged 60–89 Years *

	Hip Pain level		
Back Pain Level	None (0)	Mild (1)	Severe (2)
None (0)	464	3	13
Mild (1)	273	16	20
Severe (2)	73	2	14

* Lumbopelvic pain (LPP) level is the sum of back pain level and hip pain level, not to exceed 2. Thus, 464 persons had a LPP score of 0 (no shading), 276 had a score of 1 (light shading) and 138 had a score of 2 (darkest shading).

Table 2

Baseline Characteristics by Lumbopelvic Pain Category

Characteristic	None	Mild	Severe
N = 878, No.	464	276	138
Age, mean (SD), y	72.7 (8.1)	71.2 (8.2)	69.4 (7.2)
Male, %	49.6	50.7	44.9
Black, %	21.8	21.4	37.0
Health status and behaviors			
Current or recent smoker, %	3.0	3.3	5.1
BMI, mean (SD) kg/m ²	26.6 (4.2)	27.4 (4.9)	28.2 (5.0)
Any knee pain, %	3.7	6.5	15.2
Sedentary (active <30 minutes/week), %	28.9	35.9	44.9
Physically active ≥150 minutes/week, %	42.5	38.4	36.2
Mobility assessments			
Walking ability index, mean (SD), points	8.55 (1.10)	8.35 (1.27)	7.72 (1.97)
Usual gait speed, mean (SD), m/s	1.17 (0.19)	1.19 (0.22)	1.16 (0.20)
400m time, mean (SD), s	271 (46)	270 (44)	280 (56)
Energetic cost of walking, mean (SD), mlO ₂ /kg/m	.162 (.029)	.164 (.030)	.163 (.031)

Table 3

Association* between lumbopelvic pain status from index to follow-up visit and follow-up mobility level, mobility change and percent experiencing meaningful decline

LPP over time	N	Follow-up value	Change from index to follow-up	Meaningful decline (%)
Reported Walking Ability (points)				
Absent	252	8.30	-0.22	21.7
Resolved	94	8.35 p=.805	0.07 p=.105	14.4 p=.143
New onset	92	7.94 p=.056, p=.073	-0.42 p=.232, p=.019	28.8 p=.154, p=.016
Persistent	228	7.77 p<.001, p=.003	-0.50 p=.031, p=.001	29.1 p=.052, p=.003
Usual Gait Speed (m/s)				
Absent	253	1.146	-0.025	34.2
Resolved	94	1.148 p=.923	-0.035 p=.642	37.9 p=.489
New onset	92	1.125 p=.370, p=.409	-0.035 p=.620, p=.978	27.8 p=.224, p=.114
Persistent	228	1.137 p=.508, p=.629	-0.029 p=.805, p=.785	30.8 p=.384, p=.180
Fast 400m Walk Time (s)				
Absent	240	281.5	16.9	24.0
Resolved	89	281.9 p=.938	15.7 p=.765	27.6 p=.451
New onset	88	281.2 p=.973, p=.926	10.8 p=.138, p=.322	27.8 p=.437, p=.984
Persistent	213	285.1 p=.447, p=.607	14.3 p=.417, p=.747	30.2 p=.094, p=.600
Energetic Cost of Walking (VO ₂ ml/kg/m)				
Absent	203	.159	-.004	25.8
Resolved	76	.162 p=.357	-.003 p=.889	24.3 p=.796
New onset	69	.158 p=.957, p=.426	-.002 p=.662, p=.802	32.3 p=.283, p=.270
Persistent	158	.161 p=.460, p=.750	-.004 p=.876, p=.796	28.4 p=.589, p=.500

* Adjusted for age, age-squared, sex, race, height, weight, smoking, activity level, length of follow-up and baseline mobility for change and meaningful decline only. P-values in the "Resolved" row compare resolved and absent groups. The first p-value in the "New onset" row compares new onset with absent and the second p-value compares new onset with resolved. The first p-value in the "Persistent" row compares persistent with absent and the second p-value compares persistent with resolved. Total N available for follow-up and change analyses were 666 for walking ability, 667 for usual gait speed, 630 for 400m walk time and 506 for the energetic cost of walking.