Investigation of Weight-Bearing Symmetry in A Group of Athletes with Low Back Pain and Healthy People during Gait

Article *in* Journal of Mechanics in Medicine and Biology · August 2017

DOI: 10.1142/S0219519417500865

6 authors, including:

Meissam Sadeghisani
Shahid Beheshti University of Medical Sciences

Vahid Sobhani

Ali Asnaashari
Iran Medical Council

Hadi Azimi
Shahid Beheshti University of Medical Sciences

Journal of Mechanics in Medicine and Biology
Vol. 17, No. 5 (2017) 1750086 (9 pages)

DOI: 10.1142/S0219519417500865

INVESTIGATION OF WEIGHT-BEARING SYMMETRY IN A GROUP OF ATHLETES WITH LOW BACK PAIN AND HEALTHY PEOPLE DURING GAIT

MEISSAM SADEGHISANI[*,¶], VAHID SOBHANI[*,||], MAJID MOHSENI KABIR[†], ALI ASNAASHARI[‡], PEYMAN RAHMANI[‡] and HADI AZIMI[§]

[*]*Exercise Physiology Research Center, Baqiyatallah University of Medical Sciences, Tehran, Iran*

[†]*Emam Ali Hospital, Shahrekord, Iran*

[‡]*Neurosurgeon, Shahrekord University of Medical Sciences, Iran*

[§]*Department of English Language Teaching, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
[¶]*Sadeghi.m@sbmu.ac.ir*
[||]*entezar.pt85@yahoo.com*

Received 16 September 2015
Accepted 13 November 2016
Published 21 July 2017

The asymmetrical loading applied to legs was proposed as a risk factor for low back pain development. However, this proposed mechanical risk factor was not investigated in the athletes with LBP engaged in rotational demand activities. The aim of the present study was to examine symmetry of weight-bearing in patients with rotational demand activities compared to that in healthy people during gait. In total, 35 subjects, 15 males with LBP and 20 males without LBP, participated in the study. The participants were asked to walk 12 trials in gait lab. Forces applied to legs were recorded by a force plate. Then, the peaks of anteroposterior, mediolateral, and vertical forces were measured. Next, the asymmetrical loads applied to the legs were calculated. The results of our study demonstrated that people with LBP exhibit more asymmetry of vertical peak forces in heel strike and mid-stance. They also exhibited more asymmetry of loading in the anterior direction. But the mean values of ASI of mediolateral and posterior forces in these participants were not significantly different compared to those in the control group. It can be concluded that, in comparison to the healthy subjects, patients with LBP walk with a greater magnitude of asymmetrical weight-bearing at a comfortable speed.

Keywords: Low back pain; gait; athletes; asymmetry; force plate.

1. Introduction

Low back pain and its associated impairments are a common cause of disability in societies.[1] So, low back pain is the first reason of referral to the physical therapy clinics.[2] Nonspecific chronic low back pain is known as low back pain with duration

[||]Corresponding author.

of more than 3 months symptoms without pathological findings.[3] Low back pain is responsible for heavy direct and indirect burden on societies. Although it is known as a multifactorial problematic condition,[4–8] mechanical factors have been proposed as the prominent factor by some authors.[9–11]

In the previous studies, compensatory motion in the lumbar spine, asymmetrical motion in the lumbar spine and lower extremities, and decrease in endurance and strength are among the mechanical factors reported to be related to low back pain.[12–17]

Low back pain symptoms have been frequently reported in athletes who play rotational demand sports activities such as tennis, golf and etc.[18,19] Any musculoskeletal pain syndrome such as low back pain can result in limiting their level of sports activities and even leaving the activities.

By determining the potent mechanical impairments and correcting them, we would be able to help them. For this reason, some mechanical characteristics such as kinematic, kinetic, and myoelectrical parameters were investigated in these patients groups.[20–27]

The asymmetrical loading, as a kinetic parameter, on the lower extremities in people with musculoskeletal disorders such as low back pain was given attention by some examiners.[28–30] It has been proposed that asymmetrical weight bearing distribution might be associated with asymmetrical loading in the lumbar spine tissues that can eventually cause low back pain symptoms.[30,31] Therefore, examining the pattern of loading on the lower limbs during functional activities, such as gait, can be an important purpose of low back pain studies.

Although asymmetrical motions of the lumbar spine and lower limbs were reported in the previous studies,[26,27] to date, no study has examined whether asymmetrical loading exists in athletes with low back pain who have rotation-related sports activities or not. So, the aim of the present study was to clarify what differences may exist in the pattern of weight-bearing distribution of athletes with low back pain in comparison to healthy people during gait.

2. Materials and Methods

2.1. *Subjects*

Our study was approved by Baqiyatallah University of Medical Sciences Research ethics committee, and subjects provided written informed consent. In total, 35 subjects including 15 people with low back pain and 20 people without any experience of low back pain were enrolled in the study. Patients had nonspecific chronic low back pain,[32] diagnosed by a physician. Pain symptoms in the patients group were related to their specific activities. They had minimum 2 sessions of sports activities such as tennis, golf, and squash. Healthy subjects were recruited from the staff members of our university. Exclusion criteria included a history of spine, hip and knee surgery, obvious thoracic kyphosis and spinal scoliosis, rheumatological and immunological disease, spinal infection and tumor, and degenerative joint disease in the lumbopelvic and lower extremities joints.

Table 1. Demographic characteristics of groups.

Demographic variable	Healthy group ($N = 20$) Mean (±SD)	Group with LBP ($N = 15$) Mean (±SD)	Degrees of freedom (39), p-value
Age (years)	29 (± 5.7)	31.5 (± 7.7)	$df = 33,\ p = 0.25$
Height (m)	1.77 (± 0.06)	1.77 (± 0.06)	$df = 33,\ p = 0.05$
Weight (kg)	74.9 (± 11.3)	80.5 (± 11.4)	$df = 33,\ p = 0.87$
MBI (kg/m^2)	23.8 (± 3.4)	25.6 (± 3.7)	$df = 33,\ p = 0.05$
Duration of LBP (month)	NA	20 (± 18.2)	
Intensity of pain	NA	2.2 (± 2.0)	
Oswestry score	NA	15.2 (± 9.7)	
Fear-avoidance during physical activity	NA	14.2 (± 5.6)	
Fear-avoidance during work	NA	16.6 (± 8.5)	
Habitual physical activity	NA	9.2 (± 1.3)	

A short questionnaire related to demographical characteristics of subjects was obtained from all the participants. The participants with low back pain also completed a visual analog scale questionnaire,[33] a Baecke habitual physical activities questionnaire,[34] an Oswestry disability questionnaire,[35] and a fear-avoidance questionnaire.[36] Information about these questionnaires is shown in Table 1.

2.2. *Test*

The participants were asked to walk 12 trials in gait lab with 10 m distance with a comfortable speed.

2.3. *Instruments*

We used a Kistler force plate to record the applied loads on the limbs. The data of the force plate were recorded with a frequency of 120 Hz. Then, the data were filtered using a Butterworth filter with cut-off frequency of 10 Hz. For each trial, the peaks of the forces in vertical, anteroposterior, and Mediolateral directions, applied on dominate and nondominate legs, were determined (Fig. 1). We also used a motion analysis system to record the kinematic features of each trial test. Figure 1 shows a sample of peak forces applied on a leg.

In the following, the side-by-side asymmetry of applied loading on lower limbs was determined for each participant, according to the asymmetry index measure.[37] This index was proposed by Herzog *et al.* as shown below:

$$\mathrm{ASI} = 2\frac{X\,\mathrm{right} - X\,\mathrm{left}}{X\,\mathrm{right} + X\,\mathrm{left}} \cdot 100.$$

2.4. *Statistical analysis*

We have used SPSS software, version 21, for our statistical analysis. As the K–S test revealed that the data were normally distributed, we employed the independent t-test to compare the two groups.

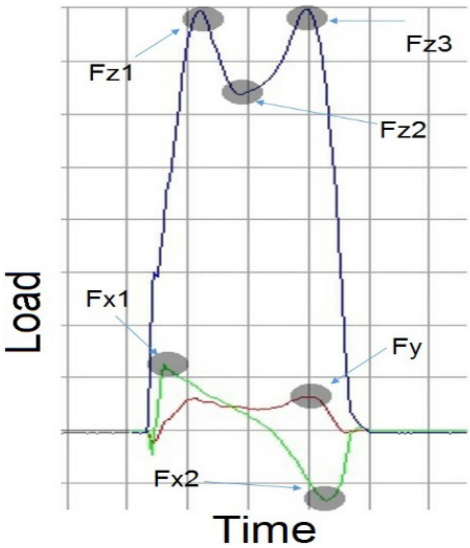

Fig. 1. The Mediolateral (—), anteroposterior (—), and vertical forces (—) applied on the leg of a subject.

3. Results

As the demographical results are demonstrated (Table 1), there was no significant difference between two groups regarding their age, height, weight and BMI (p-value > 0.05).

With regard to spatiotemporal variables (Table 2), there was no significant difference in mean values of velocity, stride length, and cadence of dominant side between healthy participants and patient participants (p-value < 0.05).

The results also show that the patients group walked with more side-by-side asymmetry in cadence and walking speed of the test compared to the control participants ($p < 0.05$).

Table 3 summarizes the mean values of ASI of loads applied on the legs in three directions. The kinetic variables revealed that in the vertical direction, the LBP group had a greater magnitude of asymmetry in weight bearing in heel strike (Fz_1) and mid stance (Fz_2) of the tests (p-value < 0.05). But the amount of ASI of peak of vertical loading during push off (Fz_3) was not different between two groups.

Table 2. Spatiotemporal variables of groups (dominant leg).

	Patients group	Healthy group	p Value
Stride length (m)	1.24 ± 0.06	1.28 ± 0.12	0.23
Velocity (m/s)	1.1 ± 0.1	1.1 ± 0.2	0.35
Cadence (steps/min)	111.2 ± 8.8	103.1 ± 13.2	0.06

Table 3. Amount of ASI for anteroposterior, Mediolateral and vertical peak forces.

Variable	Walking speed	Cadence	Stride length	Stride time	Fz1	Fz2	Fz3	Fy	Fx1	Fx2
Patient group	6.3 ± 4.8	4.2 ± 4.8	2.4 ± 1	4.2 ± 4.8	5.7 ± 3.1	4.1 ± 4.4	3.6 ± 1.9	9.9 ± 7.4	15.7 ± 11.1	9.4 ± 8.7
Healthy group	1.5 ± 1.8	1.7 ± 1.6	2.3 ± 2	2.6 ± 3.5	3 ± 3.1	1.8 ± 1.1	2.3 ± 2.4	15.9 ± 21.8	8.7 ± 7.4	12.5 ± 9.4
p-value	**0.00**	**0.04**	0.82	0.27	**0.02**	**0.04**	0.17	0.34	**0.04**	0.36

Fz: vertical force, F_y: Mediolateral Force, F_x: anteroposterior force.

As Table 3 shows, the amount of ASI of peak of anterior (Fx_1) and posterior (Fx_2) force in the LBP subjects compared to the healthy subjects were 15.7 ± 11.1, 8.7 ± 7.4 and 9.4 ± 8.7, 12.5 ± 9.4, respectively.

The result of our study shows that in the Mediolateral (Fy) direction, the mean value of ASI in the LBP people was 9.9 ± 7.4 compared to 15.9 ± 21.8 in the healthy people (p-value = 0.34).

4. Discussion

Low back pain and its associated impairments are a common reporting musculoskeletal disorder experienced by most of people.[38]

Although these impairments are multifactorial conditions,[1,6,8] in most cases mechanical factors are the prominent factors in the development of symptoms.[10] Manifestation of mechanical LBP is exacerbation of symptoms by physical activity and alleviation of symptoms by rest.[10] Therefore, various investigators addressed mechanical risk factors in LBP people in their studies.

The prevalence of LBP in athletes who were engaged in rotational demand sports activities was also reported a lot. So, the relationship between LBP and some mechanical risk factors in this patient group was studied.[16,20–24,26,27,39] The literature reveals asymmetrical kinematic variables of lower limbs movements in athletes with rotational sports activities who had LBP.[26,27,39] But to date, there is no information regarding the weight-bearing asymmetry during walking in these patients. While asymmetrical loading on the lower limbs during functional activities such as walking and sit-to-stand is known as a cause of musculoskeletal syndromes like LBP,[30,31,40,41] it has been believed that asymmetrical loading can be a cause of some problematic progressive degeneration and correlated morbidities such as osteoporosis, osteoarthritis, scoliosis and muscle atrophy.[42] So, this mechanical risk factor has been given attention in people with musculoskeletal problems such as the LBP and amputation.[41–43] Therefore, the aim of present study was to investigate the symmetry of loading applied on the legs of patients with LBP who played rotational demand sports activities.

Figure 1 shows a sample of anteroposterior, Mediolateral and vertical loading applied on a leg during gait.

To date, symmetry of weight-bearing during gait and standing has been investigated in healthy and LBP groups.[30,31,41] Burnett and *et al.* demonstrated that healthy people walk with symmetry of loading on the legs.[31] In two other studies, patients with LBP were compared with healthy people. The results of these studies were inconsistent with each other. Children and associates observed that people with LBP had more asymmetry of loading on legs compared to healthy people during standing.[41] But, Zahraee *et al.* did not see any significant difference in the ASI of the forces applied on legs between people with and without history of LBP.[30]

Although there was no significant difference between the LBP people and the healthy participants of the current study in the mean values of ASI of peak of forces in Mediolateral and posterior directions, the results of our study were more consistent with those of Child *et al.* study.[41] We observed that the LBP people walked with more asymmetry of vertical loading during heel strike and mid-stance phases of the test. The asymmetrical walking speed and cadence of the legs which were observed in the patients group could be a reason for unequal forces applied on the legs.

Our results may be important for clinical situation and clinicians who work on LBP of athletes of sports such as golf, tennis, and squash. The asymmetrical weight-bearing of the individual with LBP can be a biomechanical risk factor which can be associated with asymmetrical loading on the lumbopelvic soft tissues. This pattern of loading has been proposed as a mechanism in the development of micro-trauma and eventually macro-trauma. It was proposed that the repetition of asymmetrical loading can result in the persistence of LBP symptoms. Therefore, correction of this impairment must be given attention in general population and athletes with LBP.

As the results exhibited, our findings were in contrast to those of Zahraee *et al.* study. One reason may be related to the participants of the studies. In our study, only males participated. But, all participants of the Zahraee *et al.* were females and their specific tasks were not cleared. In addition, they believed that no difference between groups could be related to the fact that asymmetry in load bearing was not a symptom among their participants.[30]

Finally, there are some potential limitations in our study. First, we only measured the forces applied on lower limb during gait. It is recommended that in the future researches, the moment and forces applied on the leg during gait and other functional activities be examined. Second, differences in weight-bearing asymmetry between males and females were not investigated in the study. We recommend that in the future studies, sex differences be examined. Third, limited athletes with LBP participated in the study. It seems that more participants were required. There is hope that future studies would pay more attention to these limitations.

5. Conclusion

The LBP group exhibits more asymmetry of vertical loading during gait in heel strike and mid-stand phases. The LBP group also exhibits more asymmetry of peak anterior loading on the legs during gait than the healthy people. It can be concluded that the asymmetry of weight-bearing can be a reason for LBP symptoms in athletes with rotational demand activities.

Acknowledgments

I would like to thank all of those who helped me in data collection and processing.

References

1. Sadeghisani M, Shaterzadeh MJ, Rafiei AR, Salehi R. Pain, disability, fear-avoidance and habitual physical activity in subjects with low back pain with and without trunk and hips rotational demand sport activities. *J Res Rehabil Sci* **9**(8):1213–1221, 2014.
2. Jette AM, Davis KD, A comparison of hospital-based and private outpatient physical therapy practices, *Phys Ther* **71**(5):366–375, 1991. discussion 76–81.
3. Krismer M, Van Tulder M, Low back pain (non-specific), *Best Practice & Res Clin Rheumatol* **21**(1):77–91, 2007.
4. Andersson GB, Epidemiological features of chronic low-back pain, *Lancet* **354** (9178):581–585, 1999.
5. Crombez G, Vlaeyen JW, Heuts PH, Lysens R, Pain-related fear is more disabling than pain itself: Evidence on the role of pain-related fear in chronic back pain disability, *Pain* **80**(1–2):329–339, 1999.
6. O'Sullivan P, Diagnosis and classification of chronic low back pain disorders: Maladaptive movement and motor control impairments as underlying mechanism, *Man Ther* **10**(4):242–255, 2005.
7. Woby SR, Watson PJ, Roach NK, Urmston M, Are changes in fear-avoidance beliefs, catastrophizing, and appraisals of control, predictive of changes in chronic low back pain and disability? *Eur J Pain* **8**(3):201–210, 2004.
8. Kamper SJ, Apeldoorn AT, Chiarotto A, Smeets RJ, Ostelo RW, Guzman J *et al.*, Multidisciplinary biopsychosocial rehabilitation for chronic low back pain: Cochrane systematic review and meta-analysis, *BMJ* **350**:h444, 2015.
9. Adams MB, Burton K, Dolan P, *The Biomechanics of Back Pain*, Churchill Livingstone, Edinburgh, England, 2002.
10. Diamond S, Borenstein D. Chronic low back pain in a working-age adult, *Best Pract Res Clin Rheumatol* **20**(4):707–720, 2006.
11. Sahrmann S, *Diagnosis and Treatment on Movement Impairment Syndromes*, MO, Mosby, St Louis, 2002.
12. Burnett AF, Cornelius MW, Dankaerts W, O'Sullivan PB, Spinal kinematics and trunk muscle activity in cyclists: A comparison between healthy controls and non-specific chronic low back pain subjects-a pilot investigation, *Man Ther* **9**(4):211–219, 2004.
13. Cibulka MT, Strube MJ, Meier D, Selsor M, Wheatley C, Wilson NG, Irrgang JJ, Symmetrical and asymmetrical hip rotation and its relationship to hip rotator muscle strength, *Clin Biomech* **25**(1):56–62, 2010.
14. Esola MA, McClure PW, Fitzgerald GK, Siegler S, Analysis of lumbar spine and hip motion during forward bending in subjects with and without a history of low back pain, *Spine* **21**(1):71–78, 1996.
15. Luomajoki H, Kool J, de Bruin ED, Airaksinen O, Movement control tests of the low back; evaluation of the difference between patients with low back pain and healthy controls, *BMC Musculoskelet Disord*, **9**:170, 2008.
16. Murray E BE, Twycross-Lewis R, Morrissey D, The relationship between hip rotation range of movement and low back pain prevalence in amateur golfers, *Phys Ther Sport*, **10**(4):131–135, 2009.
17. Swain C, Redding E, Trunk muscle endurance and low back pain in female dance students, *J Dance Med Sci* **18**(2):62–66, 2014.

18. Finn C, Rehabilitation of low back pain in golfers: From diagnosis to return to sport. *Sports Health*, **5**(4):313–319, 2013.
19. Lindsay DM, Vandervoort AA, Golf-related low back pain: A review of causative factors and prevention strategies, *Asian J Sports Med* **5**(4):e24289, 2014.
20. Campbell A, Straker L, O'Sullivan P, Elliott B, Reid M. Lumbar loading in the elite adolescent tennis serve: Link to low back pain, *Med Sci Sports Exerc* **45**(8):1562–1568, 2013.
21. Cole MH, Grimshaw PN, Trunk muscle onset and cessation in golfers with and without low back pain, *J Biomech* **41**(13):2829–2833, 2008.
22. Cole MH, Grimshaw PN, The crunch factor's role in golf-related low back pain, *The Spine J* **14**(5):799–807, 2014.
23. Grosdent S, Demoulin C, Souchet M, Tomasella M, Crielaard JM, Vanderthommen M, Trunk muscle profile in elite tennis players with and without low back pain, *J Sports Med Phys.* **55**(11):1354–1362, 2015.
24. Tsai YS, Sell TC, Smoliga JM, Myers JB, Learman KE, Lephart SM, A comparison of physical characteristics and swing mechanics between golfers with and without a history of low back pain, *J Orthop Sports Phys Ther* **40**(7):430–438, 2010.
25. Scholtes SA, Gombatto SP, Van Dillen LR, Differences in lumbopelvic motion between people with and people without low back pain during two lower limb movement tests, *Clin Biomech* **24**(1):7–12, 2009.
26. Vad VB, Gebeh A, Dines D, Altchek D, Norris B, Hip and shoulder internal rotation range of motion deficits in professional tennis players, *J Sci Med Sport* **6**(1):71–75, 2003.
27. Van Dillen LR, Bloom NJ, Gombatto SP, Susco TM, Hip rotation range of motion in people with and without low back pain who participate in rotation-related sports, *Phys Ther Sport* **9**(2):72–81, 2008.
28. Burnett D, Campbell-Kyureghyan N, Topp R, Quesada P, Asymmetry in vertical ground reaction force and hip range of motion in asymptomatic subjects and total knee arthroplasty patients either with or without back pain, *Gait Posture* **30**:S142–S3, 2009.
29. Duffell LD, Gulati V, Southgate DF, McGregor AH, Measuring body weight distribution during sit-to-stand in patients with early knee osteoarthritis, *Gait Posture* **38**(4):745–750, 2013.
30. Zahraee MH, Karimi MT, Mostamand J, Fatoye F, Analysis of asymmetry of the forces applied on the lower limb in subjects with nonspecific chronic low back pain, *BioMed Res Int* **2014**:289491, 2014.
31. Burnett DR, Campbell-Kyureghyan NH, Cerrito PB, Quesada PM, Symmetry of ground reaction forces and muscle activity in asymptomatic subjects during walking, sit-to-stand, and stand-to-sit tasks, *J Electromyogr Kinesiol* **21**(4):610–615, 2011.
32. Krismer M, Van Tulder M, Low back pain group of the bone and joint health strategies for Europe project. Strategies for prevention and management of musculoskeletal conditions. Low back pain (non-specific), *Best Pract Res Clin Rheumatol* **21**(1):77–91, 2007.
33. Jensen MP, Turner JA, Romano JM, What is the maximum number of levels needed in pain intensity measurement? *Pain* **58**(3):387–392, 1994.
34. Baecke JA, Burema J, Frijters JE, A short questionnaire for the measurement of habitual physical activity in epidemiological studies, *Am J Clin Nutr* **36**(5):936–942, 1982.
35. Mousavi SJ, Parnianpour M, Mehdian H, Montazeri A, Mobini B, The Oswestry disability index, the Roland-Morris disability questionnaire, and the Quebec back pain disability scale: Translation and validation studies of the Iranian versions, *Spine* **31**(14): E454–E459, 2006.

36. Rostami M, Noorian N, Mansournia MA, Sharafi E, Babaki AE, Kordi R, Validation of the Persian version of the fear avoidance belief questionnaire in patients with low back pain, *J Back Musculoskelet Rehabil* **27**(2):213–221, 2014.
37. Herzog W, Nigg BM, Read LJ, Olsson E, Asymmetries in ground reaction force patterns in normal human gait, *Med Sci Sports Exerc* **21**(1):110–114, 1989.
38. Hoy D, Brooks P, Blyth F, Buchbinder R, The epidemiology of low back pain, *Best Pract Res Clin Rheumatol* **24**(6):769–781, 2010.
39. Vad VB, Bhat AL, Basrai D, Gebeh A, Aspergren DD, Andrews JR, Low back pain in professional golfers: The role of associated hip and low back range-of-motion deficits, *Am J Sports Med* **32**(2):494–497, 2004.
40. Van Dillen LR, Gombatto SP, Collins DR, Engsberg JR, Sahrmann SA, Symmetry of timing of hip and lumbopelvic rotation motion in 2 different subgroups of people with low back pain, *Arch Phys Med Rehabil* **88**(3):351–360, 2007.
41. Childs JD, Piva SR, Erhard RE, Hicks G, Side-to-side weight-bearing asymmetry in subjects with low back pain, *Man Ther* **8**(3):166–169, 2003.
42. LeMoyne R, *Advances for Prosthetic Technology.* Springer, Germany, 2016.
43. Shafizadegan Z, Karimi MT, Shafizadegan F, Rezaeian ZS, Evaluation of ground reaction forces in patients with various severities of knee osteoarthritis, *J Mech Med Bio* **16**(2):1650003, 2015.