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Research Article

Comparison of the Mechanical Energy Transfer of Gait in Female Athletes with and without Non-Specific Chronic Low Back Pain

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Abstract

Background: Low back pain (LBP) is one of the prevalent injuries among athletes. This study aimed to compare the mechanical energy transfer of gait in female athletes with and without non-specific chronic low back pain.
Methods: In this cross-sectional study, based on convenience sampling method, we selected a total of 14 females with NSCLBP and 14 females without a history of LBP who referred to Tehran physiotherapy clinics . To capture marker trajectories and ground reaction forces, we used a Vicon 6 camera motion capture system (Vicon MX, Oxford Metrics, UK), which was synchronized with two ground embedded force plates (Kistler, Winterthur, Switzerland). We performed gait analysis in the biomechanics laboratory of the University of Social Welfare and Rehabilitation Sciences. The independent t-test analyzed the data. All analyses were performed at a confidence level of 95% (P<0.05).
Results: The mechanical energy transfer in female athletes with LBP differed from athletes without LBP (P=0.037). There were no significant statistical differences between the ankle and knee joints regarding mechanical energy transfer (P>0.05).
Conclusion: Our study showed that female athletes with LBP had higher eccentric mechanical energy compensation coefficient in the hip joint, which is possibly a compensatory mechanism for lumbosacral region disorders.

Keywords: Female, Athletes, Low back pain, Hip

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1. Introduction

Low back pain (LBP) is one of the common injuries among athletes (1). It may negatively affect daily living functions, quality of life, and ability to work, possibly resulting in enormous costs for healthcare systems (2). The common recurrence of LBP and the high chances of it becoming chronic may explain the high burden associated with LBP (3). Most LBPs are categorized as non-specific chronic LBP (NSCLBP), meaning health care providers could not determine the specific pathoanatomical cause of the pain (4). Therefore, the treatment of LBP remains a challenging dilemma.

Considering there is no clear pathoanatomical cause for NSCLBP, recent treatment options focused on reducing pain and its consequences (4). Several treatment options were previously recommended for LBP, such as electrical stimulation, analgesic medicines, spinal manipulations, exercise training, education, and reassurance (5); however, none of these approaches were superior over the other (6). Therefore, this treatment failure may be ascribed to the poor knowledge of the underlying mechanisms of NSCLBP.

NSCLBP is more common in athletes with repetitive movements, which exposes some of the body structures under repetitive movements and loading (7). Besides, it is a known fact that athletes with NSCLBP perform their activities with different movement patterns compared to athletes without LBP (7, 8). Based on the kinesiopathologic model of musculoskeletal pain disorders, it seems that movement deviations existing in healthy subjects or subjects with NSCLBP may predispose them to further injuries (9). Therefore, several studies were conducted to determine these movement deviations and suggest a more effective plan of care for athletes with NSCLBP (10-12).

In this regard, Movahed et al. (2019)showed that female volleyball athletes with NSCLBP landed with more lumbar extension angle (10). Other studies found different knee and hip kinematics among LBP athletes performing double leg drop-jump (11). Moreover, studies comparing gait biomechanics of athletes with LBP found either symmetrical loads on the lower extremities in comparison to athletes without LBP (13), or higher weight-bearing asymmetry compared tonon-athletes without LBP (14). These findings showed that athletes with NSCLBP walked with different movement patterns; however, to our knowledge, there is no study on mechanical energy transfer in athletes with NSCLBP.

To have an efficient gait, individuals should have proper energy-conserving exchanges between lower extremity segments. They also need to utilize strain energy in tendons to have proper energy storage and return mechanisms (15). Previously, mechanical powers across lower extremity joints were investigated via utilizing energy flow analysis (15, 16). Some studies showed that mechanical energy transfer might change by use of prosthetic limbs at push-off (15), aging (16), and walking with two minimalist shod conditions (17).

It is currently known that athletes with NSCLBP walk and perform certain sport-specific tasks in ways different from athletes without LB; these changes may be observed as kinematic or kinetic alterations in the athletes (7, 10-12); however, there is no research regarding mechanical energy transfer in athletes with NSCLBP. Therefore, this study aimed to compare the mechanical energy transfer of gait in female athletes with and without non-specific chronic low back pain.

2. Methods

2.1. Participants: Thirty elite female athletes with a history of membership in Iranian national teams or Iranian league first divisions of volleyball, basketball, and handball volunteered in this cross-sectional study, 2018. We found no study directly examining this issue; however, considering the previous study (11), using G*Power ver 3.1 software, and considering $\alpha=0.05$ and $\beta=0.10$ for independent samples t-test of hip flexion angle in the athletes with and without NSCLBP (NSCLBP=73.62±11.06, without LBP=62.88±7.03), a total sample size of 28 was obtained. Based on convenience sampling method, we included a total of 14 females with NSCLBP and 14 females without a history of LBP who referred to Tehran physiotherapy clinics. The inclusion criteria for athletes with NSCLBP was a minimum three-year history of team membership involving at least three sessions of training per week, age range of 18 to 25 years, nonspecific localized pain in the sacro-lumbar area (from T12 to S2 vertebras), more than three months history of LBP, Body Mass Index of 18-25 Kg/m^2, and pain exaggerate with some movements (to identify mechanical pain). Exclusion criteria for both groups were athletes with a history of red flags (to exclude possible serious pathology) (18), obvious postural malalinement based on the New York posture assessment tool, history of surgery in sacro-lumbar area, history of knee ligament reconstructions, history of complete ligament rupture in the ankle (with or without a history of surgery), pregnancy or history of childbirth, report of exaggerated pain while walking or running, referral pain to the buttocks or lower extremity, and a pain intensity of above 4 based on the Visual Analogue Scale (VAS). All inclusion/exclusion criteria were checked by two expert physical therapists with at least eight years of experience in musculoskeletal disorders field. Afterwards, during a familiarization session, the participants were informed about the study aims and protocols orally and in written forms. The participants were assured that their data would remain confidential and that they could leave the study at any time. All participants were asked to study and sign the informed consent form. Afterwards, the same examiner recorded participants' demographic characteristics and set up a time for gait analysis in the laboratory.

2.2. Laboratory settings: In the laboratory, firstly the participants were asked to warm up for 10 minutes by running and general stretching exercises. Then, 29 retroreflective markers were attached to the predetermined landmarks based on the adjusted plug-in gate marker set (10). The markers were attached at the following landmarks: Sternal notch, C7, and S2 and bilateral ASIS, mid-thigh (a cluster with four markers), knee lateral epicondyle, knee medial epicondyle, mid shank (a cluster with four markers), lateral malleolus, medial malleolus, calcaneus, the first toe, and the 5th toe. After that, the participants were asked to walk at self-selected speeds on a path designated on the floor. The starting point for walking was determined from 4 meters away from the closest force plate. The participants were informed that their feet should contact the force plate while walking in the study trials. Each subject was allowed to repeat the study protocol for a maximum of three trials for more familiarization.

Before starting the test, the motion capture system and force plates were calibrated based on the manufacturer's instructions. Next, a maximum of three successful walking trials was captured. Successful trial was defined as a trial in which each foot touched the ipsilateral force plate. The study variables were extracted from three trials, and their mean average was used for data analysis. Data were recorded at a sampling frequency of 200 Hz for the motion capture system and 1000 Hz for the force plates. Vicon Workstation version 4.6 was used for data collection. Butterworth's fourth-order low-pass filter filtered the data at a cut-off frequency of 10 Hz.

2.3.Tools: Previously proved as a high-reliability tool (19), VAS was utilized to assess pain intensity. To capture marker trajectories and ground reaction forces, we used a Vicon 6 camera motion capture system (Vicon MX, Oxford Metrics, UK), which was synchronized with two ground embedded force plates (Kistler, Winterthur, Switzerland).

Data extraction: After collecting the data and naming the markers in the Vicon Workstation, raw data were converted to excel files and imported to MATLAB software for analysis. Data were analyzed using a MATLAB software by a biomechanics specialist. Standard procedures were used to interpolate the missing data shorter than 20 frames. The lower limb kinematics and kinetics were extracted according to a previous study (17).As a measure for energy transfer, the eccentric and concentric mechanical energy compensation coefficient was then calculated using the method previously explained by McGibbon et al. (20).

2.4.Statistical Analysis: Using SPSS version 21, we performed descriptive statistics and inferential analysis. Shapiro-Wilk test was run to examine the normality distribution of data. Since all data were normally ditstributed, we conducted independent t-test to compare the mean average of the study variables between groups with and without NSCLBP for all variables, including demographic and eccentric and concentric mechanical energy compensation. All analyses were performed at a confidence level of 95% ($\alpha<0.05$).

3. Results

A total of 28 volunteer athletes participated in this study. The demographic data of the participants are summarized in Table 1. There were no significant differences between the two groups in terms of these variables.

After examining the data distribution using Shapiro-Wilk test, independent t-test was run to compare the eccentric and concentric mechanical energy compensation coefficient between female athletes with and without LBP. There were statistically significant differences in the hip eccentric mechanical energy compensation coefficient in the sagittal plane (P=0.0) between two groups. Additional data are summarized in Tables 2 and 3.

4. Discussion

The results showed that the mechanical energy transfer in female athletes with LBP differed from athletes without LBP. There were no significant statistical differences between ankle and knee joints regarding mechanical energy transfer.

Table 1: The demographic data of participants (n=14 for athletes with LBP, n=14 for athletes without LBP), Mean±SD

Variable	LBP	Control	t	P value
Age (y)	20.86±2.66	20.71±2.16	0.156	0.877
Play history (y)	7.23±3.96	7.36±3.43	-0.089	0.930
Pain history (mo)	16.45±8.34	------	------	------
Weight (kg)	62.57±9.17	62.39±7.68	0.056	0.956
Height (cm)	172.50±7.07	167.71±7.96	1.683	0.104
BMI (kg/m^2)	21.17±2.58	21.95±2.45	-0.814	0.423
Pain intensity	1.40±0.82	------	------	------

Y: years, Kg: kilograms, cm: centimeters, mo: months, m: meters, SD: standard deviation, LBP: Low back pain

Table 2: Comparison of the eccentric mechanical energy compensation coefficient in lower extremity joints between female athletes with and without LBP, *: significant differences observed

Joint	Plane of motion	LBP	Control	t	P value
Hip	Frontal	0.37±0.11	0.37±0.16	-0.61	0.952
	Sagittal	0.57±0.10	0.48±0.12	2.20	0.037*
	Longitudinal	0.54±0.10	0.54±0.14	-0.170	0.866
Knee	Frontal	0.69±0.07	0.71±0.06	-0.817	0.421
	Sagittal	0.51±0.11	0.48±0.09	0.750	0.460
	Longitudinal	0.54±0.08	0.52±0.08	0.792	0.435
Ankle	Frontal	0.46±0.07	0.43±0.07	0.998	0.328
	Sagittal	0.42±0.12	0.47±0.13	-1.093	0.258
	Longitudinal	0.36±0.09	0.34±0.13	0.618	0.542

LBP: Low back pain

Table 3: Comparing concentric mechanical energy compensation coefficient in lower extremity joints between female athletes with and without LBP

Joint	Plane of motion	LBP	Control	t	P value
Hip	Frontal	0.26±0.04	0.30±0.09	-1.432	0.164
	Sagittal	0.52±0.10	0.51±0.19	0.128	0.900
	Longitudinal	0.51±0.06	0.54±0.10	-1.161	0.256
Knee	Frontal	0.58±0.09	0.58±0.09	0.048	0.962
	Sagittal	0.53±0.10	0.55±0.11	-0.664	0.513
	Longitudinal	0.55±0.16	0.51±0.09	0.832	0.413
Ankle	Frontal	0.67±0.03	0.69±0.05	-1.056	0.300
	Sagittal	0.46±0.13	0.51±0.10	-1.039	0.308
	Longitudinal	0.39±0.13	0.36±0.12	0.653	0.519

LBP: Low back pain

Previous studies showed that athletes with LBP had different movement mechanics (10, 11) in comparison with non-LBP athletes. For instance, it was shown that LBP athletes had lower knee flexion angle in landing (11) and different spinal kinematics in cycling (21) anddancing (22).

This study showed that female athletes with LBP had different mechanical energy transfers in the hip joint. The average eccentric mechanical energy compensation coefficient was higher in female athletes than in LBP, which might be in consistent with other studies suggested that athletes with LBP may perform their exercises with compensatory movements (7). Increasing the eccentric mechanical energy compensation coefficient in the hip joint may be the result of a potential disorder in adjacent joints (23) such as disorder in lumbopelvic muscles energy production. In this line, previous studies showed that athletes with LBP might have different muscular functions and motion ranges (24, 25). This compensation may place the athletes at the risk of developing further injuries.

The stance phase of gait is a closed kinetic chain movement (26); thus, it is expected that any disorder in one joint should be transferred to other joints. However, this study demonstrated no difference between mechanical energy transfer of knee and ankle joints among female athletes with and without LBP. One explanation for this finding may be that the participants experienced only mild pain (1.40±0.82); therefore, the effect of pain on lower limb mechanics may not be evident in mild tasks like walking.

This was a cross-sectional study, so the cause-effect relationship between energy transfer and the occurrence of LBP remained unclear. We examined the energy transfer in female athletes; the results may not be generalizable to male athletes. In this study, the athletes with LBP suffered from mild pain, so it seems that the greater pain intensity may be associated with different mechanical energy transfer mechanisms.

5. Conclusion

The study showed that the female athletes with LBP had greater eccentric mechanical energy compensation coefficient in the hip joint, which is possibly a compensatory mechanism for lumbosacral region disorders.

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Ethical Approval

The Ethics Review Board of University of Social Welfare and Rehabilitation Sciences approved the present study with the following number: IR.USWR.REC.1395.33

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Conflicts of interest: None to declare.

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