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# Comparison of Isometric Strength of the Trunk and Hip Muscle Groups in Female Athletes with and without Low Back Pain: A Cross-Sectional Study

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## Abstract

**Background:** Low back pain (LBP) is a common musculoskeletal disorder in athletes. Reduced strength in hip and trunk muscles has been observed among non-athletes with low back pain. This study aimed to compare the strength of trunk and hip muscles between female athletes with and without LBP and to investigate strength association with disability level in female athletes with LBP.

**Methods:** This cross-sectional study was conducted on 26 female athletes with LBP and 30 female athletes without LBP. The strength of the trunk and hip muscles was measured using a hand-held dynamometer and the impact of LBP on the sports activities and activities of daily living was measured using the Athletes Disability Index (ADI). Data analysis was done using an independent sample t test and the Pearson correlation coefficient.

**Results:** There were no significant differences between groups for trunk and hip muscles strength ($p > 0.05$). A fair to moderate correlation was seen between the strength of the trunk, hip abductors, flexor and extensors muscles and the scores of the ADI questionnaire in the LBP group ($r = -0.26$ to $-0.48$). However, there was no significant correlation between the strength of hip adductor muscles and the scores on the ADI questionnaire.

**Conclusion:** Based on the results, the strength of trunk and hip muscles was not different between athletes with and without LBP. It is recommended that athletes' training be done during functional tasks rather than strengthening a single muscle group.

**Keywords:** Low Back Pain, Athlete, Trunk Muscles, Hip Muscles, Disability

***Conflicts of Interest:*** *None declared*
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## Introduction

Low back pain (LBP) is a common musculoskeletal complaint in athletes (1). It is reported that

athletes of particular sports disciplines such as volleyball or gymnastics are more at risk of LBP than non-athletes (2). The higher incidence of LBP in athletes might be due to the excessive forces placed on the spine during some of the movements in the sport (3).

According to the literature, trunk and hip muscles strength are the common components of the LBP (3, 4). Performing sports skills requires strong trunk and hip

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***↑What is "already known" in this topic:***
According to the literature, trunk and hip muscles weakness contributes to the development of LBP in the general population. Also, the prevalence of LBP and LBP-related disability is higher in women. However, there is limited evidence regarding the strength of the trunk and hip muscles in female athletes with LBP.

***→What this article adds:***
The results showed that the strength of trunk and hip muscles was not different between female athletes with and without LBP. Also, there was a fair to moderate correlation between the strength of trunk and hip muscles and the disability score in the LBP group.

muscles, thus an athlete who lacks muscles strength may possess an increased risk of LBP (5). Hip muscles assist in the segmental stability of the lumbar area and are essential for maintaining dynamic alignment and biomechanics of the trunk and hip joint (2, 4). Previous studies have suggested that trunk and hip muscles weakness contributes to the development of LBP in the general population (4, 6, 7). However, muscular strength is higher in athletes compared with untrained individuals (8) and there is limited evidence regarding the strength of the trunk and hip muscles in female athletes with LBP. According to the literature, LBP and LBP-related disability prevalence is higher in women (9-11). Women experience numerous physical changes during puberty, such as increased body mass, height, and decreased muscle strength, making them prone to LBP (12, 13).

To our knowledge, no study has examined the strength of the trunk and hip muscles between female athletes with and without LBP. It is essential to compare the athletes with LBP with a control group to ensure impairment detection. This study aimed to compare the strength of the trunk and hip muscles between athletes with and without LBP and to determine whether trunk and hip muscles in the LBP group are correlated with the disability level.

## Methods

### Design and Participants

A cross-sectional case-control study was conducted from November 2019 to September 2020.

The sample size was calculated using G* Power software Version 3.1.9.4. It was determined that the sample size of 26 participants in each group would be sufficient to compare the trunk and hip muscles strength between groups according to the study results of Meftahi et al (effect size d = 0.8; α = 0.05; power = 0.85) (14, 15). A total of 26 female athletes with LBP and 30 female athletes without LBP participated in this study (Table 1). All participants signed informed consent before enrollment in the study. The study was approved by the Ethics Committee of Iran University of Medical Sciences (ethic number: IR.IUMS.REC.1398.051).

Female athletes who participated in class-I (jumping, pivoting, hard cutting like basketball, handball) or class-II sports (less jumping than the level I, like volleyball, racket sports, martial arts, gymnastics) and training 3 to 6 hours per week were included in this study (16).

The athletes were included in the LBP group if they had the following items: age between 18 to 30 years, at least 2 episodes of LBP symptoms in the last year that had lasted at least 2 consecutive days, and pain intensity less than 30 mm (mild pain) on the visual analog scale (VAS) on the testing day (17). The inclusion criteria for the control group were age between 18 to 30 years, and no LBP during the last 6 months. The following exclusion criteria were considered for both groups: pregnancy, leg length discrepancy, neurologic diseases, history of surgery in the low back during the last 1 year, history of disc herniation in the low back, history of trauma in the spine during the last 1 year, rheumatoid arthritis, scoliosis, radicular pain, and excessive genu varus or genu valgus (4, 16). The groups were matched for age, weight, height, and body mass index (BMI).

### Outcome Measures

#### Trunk Muscles Strength

The strength of the trunk and hip muscles was assessed using a hand-held dynamometer (Sharifexo m-22). To achieve acceptable reliability for strength evaluations, recommendations from previous studies regarding standardized instruction and verbal encouragement, and fixation of the dynamometer were applied. The dynamometer is a simple and reliable measurement device for measuring muscles strength (respectively, abdominal muscles; inter class correlation coefficients [ICC]:0.67-0.93, hip muscles; ICC:0.90-0.94) (18, 19). The dynamometer was fixed with a strap, therefore, the examiner confounding effects such as examiner's strength, stabilization technique, and orientation of the sensor relative to the position of the limb were limited (20).

The trunk flexor muscles strength was examined in the supine position with hands behind the head. The ankles and anterior superior iliac spine (ASIS) were fixed with a belt. The dynamometer was fixed over the sternum and resistance was applied perpendicular to the trunk. The athletes were asked to build up an isometric trunk flexion (Fig. 1A).

The strength of the trunk extensor muscles was measured in the prone position with the hips flexed at a 30° angle. The ASIS and ankles were fixed by a belt, and resistance was applied perpendicular to the trunk. The dynamometer was held at the height of the 4$^{th}$ thoracic vertebrae and the participants were asked to build up an isometric trunk extension (19) (Fig. 1B).

#### Hip Muscles Strength

The hip flexors strength was assessed in a sitting position with the hip and knee at a 90° angle. The dynamometer was located above the knee and resistance was applied at the knee approximately 2 cm proximal to the femoral condyles. Then, participants were asked to flex their hips

*Table 1.* Demographic characteristics of the sample

| variable | Control group (n=30) Mean (SD) | LBP group (n=26) Mean (SD) | *P*-value |
|---|---|---|---|
| Age (year) | 18.87(1.95) | 19.81(3.17) | 0.184 |
| BMI (kg/m$^2$) | 20.92(2.59) | 21.33(3.14) | 0.593 |
| Weight (kg) | 58.10 (9.63) | 59.85 (10.38) | 0.597 |
| Height (m) | 1.67 (0.06) | 1.66 (0.05) | 0.582 |
| VAS score (maximum pain during last year) | NA | 4.25(1.16) | NA |
| ADI score (%) | NA | 18.73(8.96) | NA |

ADI= Athlete Disability Index; BMI= body mass index; LBP= low back pain; NA= not applicable; VAS=visual analogue scale.

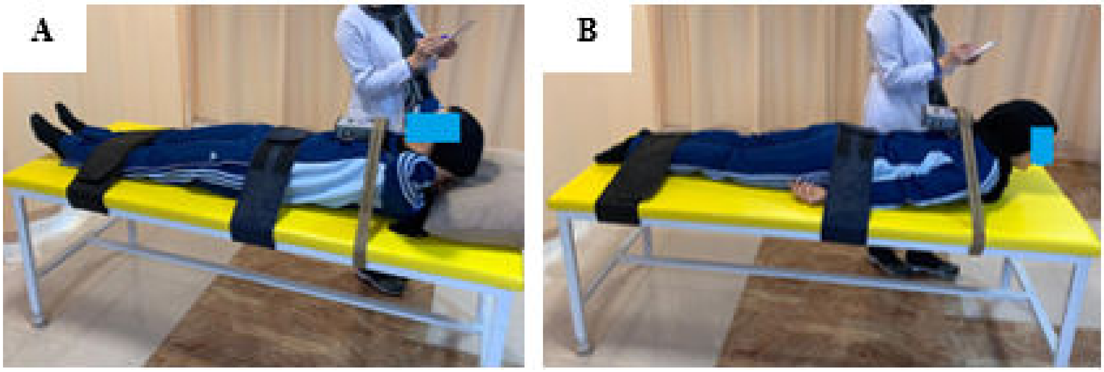


*Fig. 1.* Test position for A: Trunk flexor muscles, B: Trunk extensor muscles

(isometric contraction) (Fig. 2A).

The hip extensors strength test was done in a prone position with the knee extended. The dynamometer was fixed above the popliteal crease, and resistance was applied approximately 2 cm proximal to the popliteal crease. The participants were asked to extend their hip (isometric contraction) (Fig. 2B).

The strength of the hip abductor and adductor muscles was assessed in a side-lying position with the hip in a neutral position and the knee extended. The dynamometer was fixed over the knee joint. For assessing hip abductors strength, resistance was applied approximately 2 cm proximal to the lateral femoral condyle, and participants were asked to abduct their hip (isometric contraction) (Fig. 2C). For assessing hip adductors, the examiner held the upper leg, and resistance was applied approximately 3 cm proximal to the medial femoral condyle. Then, participants were asked to adduct the lower leg with an isometric contraction (21) (Fig. 2D). The tests were performed in a computer-established random sequence.

### Disability

Disability level was assessed in the LBP group using the Athletes Disability Index (ADI). The ADI is a 12-item questionnaire that measures the impact of LBP on the sport and exercise activities in addition to disability in activities of daily living such as stretching exercises, strengthening/weight training exercises, sport technical skills, rotational back movements/ changing direction, sitting, walking, recreational activities, sexual activity, sleep, self-care, and fear of pain or (re)injury. Each item is scored between 0 to 3, and higher scores indicate a greater perceived disability. The total scores were multiplied by 100 and then were transformed into percentages, with higher percentages representing more pain and difficulty. The Persian version of the ADI is a reliable and valid tool for assessing disability in athletes with LBP (22).


*Fig. 2.* Test position for A: Hip flexor muscles, B: Hip extensor muscles, C: Hip abductor muscles, D: Hip adductor muscles

### Procedure

Demographic data were collected for both groups. Athletes in the LBP group were asked to complete the ADI. Then, the strength of the trunk and hip muscles was measured for each subject. The participants were instructed to perform a maximal isometric contraction of the trunk and the hip muscles for each trial before measurements.

To ensure that participants achieved maximal contraction, 2 submaximal test trials were performed to familiarize the participants with the testing procedure for each position. Then, participants were asked to perform their maximal contraction. Also, verbal encouragement was provided to each participant during testing. Each contraction was held for 4 seconds (maximal isometric hold) and was repeated 3 times. The mean value of 3 isometric contractions were used for data analysis (19, 23). To minimize the influence of fatigue, participants had a 30-second resting period after each repetition and 5 minutes between changing test positions (19, 23). One examiner performed all tests.

### Statistical Analysis

The strength values of the trunk and hip muscles were normalized to the participants' BMI (Nm/kg) using the following formula: (strength/BMI) * 100 (24).

Statistical analysis was performed using the SPSS Statistics Version 24. The distribution of the data was assessed using the Kolmogorov–Smirnov test. All variables had a normal distribution. An independent sample t test was used to compare the anthropometric data and the mean values of trunk and hip muscles strength between the 2 groups. The Pearson correlation coefficient also was used to assess correlations between the strength of the trunk and hip muscles and the level of disability. Correlations were classified as "little or no" (r < 0.25), "fair to moderate" (r = 0.26 to 0.49 ), "moderate to good" (r = 0.5 to 0.74), or "good to excellent" (r > 0.75) (25). The significance level was set at $p < 0.05$.

## Results

Participants' characteristics are described in Table 1. No significant differences were found in baseline characteristics between two groups ($p > 0.05$). The results of the independent t test revealed no significant differences between groups for trunk and hip muscles strength on both sides ($p > 0.05$) (Table 2).

The results of the correlation analysis are shown in Table 3. The correlation coefficient between the normalized values of the strength of hip adductor muscles (on both sides) and the scores of the ADI questionnaire was not significant (r < -0.25). However, there was a fair to moderate correlation between the normalized values of the strength of the trunk, hip abductors, flexor, and extensors muscles, and the scores of the ADI questionnaire (r = -0.26 to -0.48).

## Discussion

The scientific literature supports the fact that impaired muscle strength is commonly seen in female athletes (26, 27). In this context, trunk and hip muscles weakness have been considered a risk factor for the development of LBP (3, 4). Also, trunk and hip muscle weakness due to LBP is a risk factor for further musculoskeletal injuries such as groin strain, noncontact anterior cruciate ligament injuries, iliotibial band syndrome, and patellofemoral pain syndrome in female athletes (27-30). To our knowledge, this was the first study to compare the strength of trunk and hip muscles between female athletes with and without LBP. The current study results revealed no significant differences in the strength of trunk and hip muscles between the groups. The results also revealed that the disability level in athletes with LBP was associated with the strength of trunk flexors and extensors, hip abductors, flexors, and extensors muscles.

Inconsistent findings have been reported regarding studies on the strength of trunk and hip muscles in the non-athlete population with and without LBP. Some studies reported no differences in the trunk and hip muscles strength between patients with and without LBP (31-33), and other studies have reported trunk and hip muscles weakness in those with LBP (4, 34).

Limited data are available in the literature regarding the differences between the trunk and hip muscles strength between athletes with and without LBP. However, in agreement with our findings, Grosdent et al and Renkawitz et al reported no differences in the isometric trunk muscles strength between elite tennis players with and without LBP (35, 36). Also, in another study, the results showed no significant differences in hip flexors muscles strength between football players with and without LBP (37). Pain might negatively impact physical activity levels and reduce muscle strength in non-athletes; most athletes with LBP return to sport as soon as the pain subsides (38). Hence, this could prevent disuse strength reduction in athletes with LBP (35).

The findings of this study showed a fair to moderate correlation between the strength of the trunk, hip abductors, flexor, extensors muscles, and the athlete's disability scores (ADI) in athletes with LBP. This instrument is re-

*Table 2.* Between groups comparison of the trunk and hip muscles' strength results

| Normalized strength (Nm/kg) | Control group (n=30) Mean (SD) | LBP group (n=26) Mean (SD) | Mean difference | 95% CI of the mean difference | *P*-value |
|---|---|---|---|---|---|
| Trunk flexors strength | 185.47 (24.32) | 184.78 (25.15) | -0.68 (6.62) | -13.96, 12.58 | 0.918 |
| Trunk extensors strength | 128.44 (44) | 116.46 (32.12) | 11.98 (8.24) | -7.92, -8.38 | 0.233 |
| Right hip flexors strength | 75.22 (21.27) | 71.93 (20.2) | 3.28 (5.54) | -6.83, 14.22 | 0.556 |
| Right hip extensors strength | 107.30 (32.68) | 115.90 (36.12) | -8.59 (9.26) | -27.03, 9.84 | 0.336 |
| Left hip flexors strength | 72.73 (19.68) | 70.40 (22.77) | 2.33 (5.73) | -8.82, 13.37 | 0.686 |
| Left hip extensors strength | 108.40 (34.10) | 114.10 (39.02) | -5.70 (9.86) | -25.29, 13.89 | 0.566 |
| Right hip ABD strength | 99.08 (32.48) | 99.84 (27.82) | -0.76 (8.05) | -17.89, 13.95 | 0.925 |
| Right hip ADD strength | 66.09 (18.87) | 64.83(20.73) | 1.25 (5.28) | -9.33, 11.84 | 0.814 |
| Left hip ABD strength | 92.43 (26.72) | 95.41(28.18) | -2.98 (7.37) | -17.76, 11.80 | 0.688 |
| Left hip ADD strength | 69.87 (69.87) | 71.50 (23.84) | -1.63 (5.48) | -12.89, 9.37 | 0.767 |

ABD=abduction; ADD=adduction; CNSLBP= chronic non-specific low back pain

*Table 3.* Pearson correlation coefficients between trunk and hip muscles strength and performance with disability level, in LBP group

| Variables | Correlation (r) with ADI score | *P*-value |
|---|---|---|
| Trunk flexors strength | -0.48 | 0.011 |
| Trunk extensors strength | -0.30 | 0.129 |
| Right hip flexors strength | -0.43 | 0.027 |
| Right hip extensors strength | -0.27 | 0.180 |
| Left hip flexors strength | -0.40 | 0.040 |
| Left hip extensors strength | -0.33 | 0.092 |
| Right hip ABD strength | -0.26 | 0.183 |
| Right hip ADD strength | -0.21 | 0.304 |
| Left hip ABD strength | -0.36 | 0.070 |
| Left hip ADD strength | -0.06 | 0.736 |

ABD=abduction; ADD=adduction; LBP= low back pain; ADI= Athlete Disability Index lated to perceived disability for performing sports tasks, which require the coordinated activity of synergistic muscle groups, such as jumping, sport technical skills, and rotational back movements/changing direction. Therefore, although strength deficits were not evident in LBP athletes, other factors such as motor control changes (eg, altered muscle timing and pattern of activation), reduced muscle endurance, and greater fatigability could be related to LBP in female athletes (35, 39).

There are some limitations to this study. Considering the multifactorial etiology of the LBP (40), this impairment is not only related to trunk and hip muscles strength. Many factors such as psychosocial factors (eg, fear-avoidance beliefs, kinesiophobia, pain catastrophizing) also play an important role related to the appearance and development of LBP (41). These factors were outside the scope of the current study and were not assessed. The Pearson correlation was used to evaluate the associations, which does not provide nonlinear relationships. Therefore, the correlational results should be interpreted cautiously. The study was conducted on amateur female athletes attending sports class type I and II, and also participants had mild pain during the testing procedure. Therefore, the results cannot be generalized to professional athletes and athletes with severe pain intensity. Another limitation is that the strength of muscle groups was examined during isometric contractions, and the strength was not assessed throughout dynamic task or functional performance tests.

## Conclusion

Based on the findings of the present study, the strength of trunk and hip muscles was not different between athletes with and without LBP. It is recommended that instead of strengthening a single muscle group, athletes' training be done during functional tasks.

***Ethical Considerations:*** IR.IUMS.REC.1398.051.

### *Conflict of Interests*

The authors declare that they have no competing interests.

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