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RESEARCH ARTICLE

COMPARISON OF FUNCTIONAL TEST SCORES ASSOCIATED TO THE NON – CONTACT LOWER EXTREMITY INJURIES AND CORE ENDURANCE IN PEOPLE WITH VARIETIES OF PELVIC TILT AND NON-PELVIC TILT

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ABSTRACT

The purpose of this study is to compare the performance scores of non-contact lower extremity injuries and endurance in core area of Shiraz (Iran) women soccer players with different types of pelvic tilt (PT) and without - Pelvic Tilt. Subjects of this study included 48 soccer players (12 without tilt) (age: 22.50 ± 1.16 years, height: 1.63 ± 0.09 m, weight: 58.33 ± 13.07 kg, BMI: 22.10 ± 5.98 kg/m^2, 12 persons with anterior tilt (Age: 22.33 ± 1.23 years, height: 1.64 ± 0.03 m, weight: 54.66 ± 14.50 and BMI: 20.28 ± 5.22), 12 persons with posterior tilt (Age: 22.83 ± 1.19 years, height: 1.62 ± 0.04 m, weight: 50.33 ± 3.91 kg, BMI 19.09 ± 1.91 and 12 patients with lateral pelvic tilt (Age: 23.00 ± 1.12 years, height: 1.64 ± 0.05 m, weight: 52.41 ± 2.74, BMI: 19.37 ± 1.67 kg/m^2, which were randomly selected. A demographic questionnaire was used to collect demographic data and sports history and a tilt gauge was used to measure pelvic tilt changes. Core endurance was assessed by McGill Endurance Test and lower extremity injury risk using Single-Leg Squat test. ANOVA was used to compare the factors in the groups and the LSD test was used to compare the two groups. The results showed that there were 60 degree flexion test (P = 0.005, F = 4.88) , Sorensen test (P = 0.03, F = 3.24) and Abdominal Plank test (P = 0.008). P, F = 4.43) , Right Plank Test (P = 0.001, F = 12.70) , Left Plank Test (P = 0.001, F = 13.06) , score of core endurance score Significant differences were observed between the groups (P = 0.001, F = 26.27) , single-leg squat test (F = 45.66, P = 0.001). There was also a better performance in subjects with normal pelvic tilt. From the results of this study, it can be concluded that there is a significant difference in endurance and performance in people with different types of pelvic tilt. An important step can be taken to correct lower extremity risk factors.

KEYWORDS

Athlete, Endurance, Plevic Tilt, Single Leg Squat, Lower Extremity Injury.

1. INTRODUCTION

Pelvic tilt is defined as the pelvic tilt (PT) relative to the horizontal plane. The amount of this tendency to stand comfortably with varying amounts has been reported. In this situation, if the superior anterior iliac spine is higher than the inferior posterior iliac spine, the pelvic is backward (posterior tilt) and if the opposite is present, the pelvic is rotated forward (anterior tilt). Otherwise, the pelvic is in neutral position. Herrington in 2011, measured the angle of tilt of the pelvic in 120 healthy individuals (65 men and 55 women) using PALM palpation. According to his results, 80% of people had pelvic anterior tilt (PAT); 6.5% had pelvic posterior tilt (PPT), and 13.5% had a neutral position (Harrington, 2011). Factors affecting PT include muscle flexibility and strength. The PAT by producing a pair of forces resulting from concurrent abdominal and thigh extensor contractions, with the hip flexor and erector spine concurrent contractions (Kendall et al., 2005; Levanagie et al., 2001).

Therefore, with variations of PT and lumbar lordosis, due to the type of muscular adhesions, some of these muscles are in elongated position, and some are in shortened position. Youdas et al, Studied the relationship between PT, lumbar lordosis, abdominal muscle length and function, lumbar muscle length, single hip flexor muscle length, BMI, Age, Sex, and level of physical activity in 90 healthy subjects aged 40-69 years. They reported that PT angle (PTA) correlated only with abdominal muscle function and only in women (r = 0.23) (Youdas et al, 1996). Various studies have found a clear relationship between the muscles of the lumbar and thigh muscles and lower limb abilities and have emphasized the important role of external hip abductors and rotators in maintaining lower limb alignment (Sadeghi et al, 2013.) , That seems to be a change in pelvic alignment and an increase in lateral tilt with the effect on these muscles may result in imbalance in these muscles which is related to the relationship between PT changes and the risk of ACL injury (Roling, 2011). In a single prospective study in athlete women lateral hip displacement, after PT was a strong predictor of ACL injury with 91% sensitivity and 68% and it is a feature (Zazulak et al., 2007). As it has been said, core muscles stabilize the core region of the body plays an important role in the prevention of sports injury (Fredericson, 2005). This area is described by controlling the movement and muscular capacity of the lumbar, hip, and thigh complex (Bobbert et al., 1999). Maintaining positional alignment and dynamic postural balance during functional activities is one of the core

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domain tasks that helps prevent false patterns (Zazulak et al., 2007). Asymmetry in position and motion does not allow the core region to be stable (Zazulak et al., 2007). Restrictions on the strength and stability of the deep muscles lead to improper exercise techniques and make the athlete susceptible to injury (Lederman, 2010).

A desirable core region maintains the normal relationship of agonist and antagonist muscle length-tension, leading to optimal joint kinematics in the lumbar and hip complexes in functional locomotor chain motions and providing maximum stability for lower extremity movements (Sato et al., 2009). Core stability as an interface with the effective transfer of force produced in the lower extremity to the upper extremity through the trunk contributes to better athletic performance (Nesser et al., 2009). The results show that the stabilizing muscles contract before the lower extremity movers and on all motion plates, which increases the stiffness of the spine to create a stable backrest. Researchers also suggest that athletes must have sufficient strength in the thigh and trunk muscles to stabilize the various movement platforms (Robinson et al., 2007.). Decreased proximal muscle strength (pelvic and thigh) creates a weak and unstable foundation for the development and application of force in the lower extremities, which this core instability can be a predictor of lower extremity injury (Brumitt, 2008).

Thus, weakness in the core muscles is directly correlated with more injury to the lower extremities, especially in exercises that require jumping, hopping and running. On the other hand, increasing core stability enhances the neuromuscular appeal of lower back pain and low back and prevents lower extremity injury (Mannion et al., 2001). Based on the findings and given the limited research available to evaluate the relationship between PT changes and core body muscle strength and the risk of lower extremity injury, this study aimed to compare the functional test scores related to non-contact lower extremity injuries and endurance of core muscles was performed in subjects with and without PT.

2. MATERIALS AND METHODS

2.1 Participants

The present study was a causal-comparative design study in which 48 females soccer players (12 without tilt, 12 with anterior tilt, 12 with posterior tilt, and 12 with pelvic lateral tilt) participated in Shiraz (Iran) 18-25 years old. Subjects were selected from among about 100 soccer based on the inclusion criteria of the study. Initially, all participants received written consent from the volunteer company. Subjects in four groups with the different tilted pelvic performed core endurance and Single Leg Squat test (SLST). Then the data from the measured measurements were analyzed, and the results were discussed based on the results. After evaluating height and weight using digital meters and digital scales, PT was measured using a tilt gauge evaluated (Harrington, 2011). Core endurance was assessed by the McGill protocol, which included 5 movements; 60-degree flexion, Sorensen, abdominal plank, right and left Plank (McGill et al., 1999).

Figure 1: Evaluate Core Endurance.

2.2 Measures

The functional test for predicting lower extremity injury in this study was the SLST. The SLST began with the athlete standing on one leg and placing his hands on the waist (or free side of the body), the non-test leg had about 45 degrees of knee flexion (KF) and maintained this position until the end of the test. The head and eyes were straight ahead. The athlete was asked to perform a controlled downward squat to a 45-degree angle (often a 90-degree angle) and return to standing on one leg while maintaining balance. If the test leg touched the ground or hit the non-test leg, the test would be repeated (Portney et al., 2009). The tester evaluated the trunk, thigh, knee and foot. Increased abduction and internal rotation of the thigh during the test indicate weak control of the thigh muscles and relying on the quadriceps to control the knee. On the other hand, a 57% increase in quadriceps activity, especially when the knee has minimal flexion, can increase displacement of the anterior tibia and sprain of the ACL (Brown et al., 2014). The test results were classified into high, good or low groups according to five criteria (Bell et al., 2011). To get a high score in an athlete's test, he or she had to meet all the requirements of four out of five criteria, and if the athlete could not meet at least one of the five criteria, his or her test score would fall to a poor grade. Test scoring may be done by recording it on the front page and viewing its video. Intra-group validity for this test has been reported in research, ICC 0.92 (Bell et al., 2011). The validity of using frontal plane projection angle (FPPA) to evaluate the dynamic knee valgus angle (DKVA) during single leg squat test for men and women was reported as 0.88 and 0.72, respectively (Earl et al., 2007).

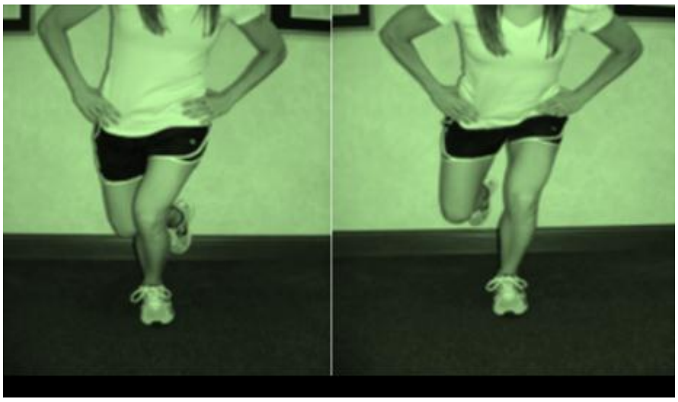

Figure 2: Single – Leg Squat test

2.3 Statistical Analysis

Shapiro-Wilk test was used to assess normal distribution of data; equality of variances was evaluated by LSD test., ANOVA and LSD post hoc tests were used to compare subjects performance tests in four groups. Statistical analysis was performed using SPSS 22 software. significance level was set at 0.05.

3. RESULTS

In this study, 48 female soccer players (12 in each group) were included. table 1 summarizes the results of descriptive statistics of female soccer players (12 without tilt, 12 with anterior tilt, 12 with posterior tilt, and 12 with lateral PT) in the four groups of normal tilt, anterior tilt, posterior tilt and lateral tilt shows.

Table 1: Desprective statistics of subjects

Variables	Without tilt pelvic	Anterior tilt pelvic	Anterior tilt pelvic	Lateral tilt pelvic
	Mean ± Standard deviation	Mean ± Standard deviation	Mean ± Standard deviation	Mean ± Standard deviation
Age (year)	22.50 ± 1.16	22.33 ± 1.23	22.83 ± 1.19	23.00 ± 1.12
Hight (m)	1.63 ± 0.09	1.64 ± 0.03	1.62 ± 0.04	1.64 ± 0.05
Wight (kg)	58.33 ± 13.07	54.66 ± 14.50	50.33 ± 3.91	52.41 ± 2.74
BMI (kg/m^2)	22.10 ± 5.98	20.28 ± 5.22	19.09 ± 1.91	19.37 ± 1.67
Mean of Tilt (dree)	7.50 ± 1.16	13.00 ± 0.60	2.00 ± 0.73	2.41 ± 0.79
Sport history (year)	4.66 ± 0.98	4.50 ± 0.90	4.91 ± 0.90	4.25 ± 0.86
N	12	12	12	12

According to Table 2, there is a significant difference between the groups in 60 degrees Flexion test scores (F = 4.88, P = 0.005) , Sorensen test (P = 0.03, F = 3.24) Abdominal plank test (P = 0.008, F = 4.43) , Right Plank test (P = 0.001, F = 12.70) , Left Plank test (P = 0.001, F = 13.06) , Core Endurance score (P = 0.001, F = 26.27) , Single Leg Squat test (P = 0.001, F = 45.66). Considering the significance of the ANOVA test, the results of the LSD post hoc test are reported.

Table 2: ANOVA test results for comparison of tests in four groups

Test	Group	Mean ± Standard deviation	Sum Squared		Df		Mean Squared		F	P - value
			Within subject	Between subject	Within subject	Between subject	Within subject	Between subject		
60 dgree flexion (s)	Without tilt	76.16 ± 7.75	1108.56	3327.91	3	44	369.52	75.63	4.88	0.005*
	Anterior tilt	68.66 ± 5.48								
	Posterior tilt	68.08 ± 8.37								
	Lateral tilt	62.66 ± 11.92								
Sorensen (s)	Without tilt	80.50 ± 6.54	819.56	3703.56	3	44	273.18	84.18	3.24	0.03*
	Anterior tilt	71.00 ± 6.46								
	Posterior tilt	69.91 ± 12.29								
	Lateral tilt	73.00 ± 10.04								
Abdominal plank (s)	Without tilt	71.16 ± 4.13	385.75	1276.16	3	44	128.58	29.00	4.43	0.008*
	Anterior tilt	65.91 ± 4.88								
	Posterior tilt	63.66 ± 7.26								
	Lateral tilt	65.08 ± 4.71								
Right plank (s)	Without tilt	77.20 ± 8.34	2165.89	2499.91	3	44	721.96	56.81	12.70	0.001*
	Anterior tilt	66.90 ± 8.17								
	Posterior tilt	62.20 ± 6.11								
	Lateral tilt	59.60 ± 7.30								
Left plank (s)	Without tilt	75.75 ± 8.60	1866.22	2094.75	3	44	622.07	47.60	13.06	0.001*
	Anterior tilt	65.91 ± 4.98								
	Posterior tilt	63.66 ± 7.19								
	Lateral tilt	58.28 ± 6.31								
Score of core endurance (s)	Without tilt	75.96 ± 3.23	1048.78	585.53	3	44	349.59	13.30	26.27	0.001*
	Anterior tilt	67.66 ± 4.14								
	Posterior tilt	65.50 ± 3.34								
	Lateral tilt	63.78 ± 3.78								
Single – leg squat	Without tilt	13.58 ± 1.16	417.75	134.16	3	44	139.25	3.04	45.66	0.001*
	Anterior tilt	8.41 ± 1.92								
	Posterior tilt	8.83 ± 2.12								
	Lateral tilt	5.33 ± 1.61								

* Indicates a statistically significant difference between groups (P≤0/05)

Table 3: Results of the LSD post hoc test to compare the tests in the four groups

Test	Group	Mean Difference	Standard Error of Mean	P - value
60 dgree flexion	Without tilt – anterior tilt pelvic	7.50	3.55	0.04*
	Without tilt – posterior tilt pelvic	8.08	3.55	0.02*
	Without tilt – lateral tilt pelvic	13.50	3.55	0.001*
	Anterior tilt – posterior tilt pelvic	0.58	3.55	0.87
	Anterior tilt – lateral tilt pelvic	6.00	3.55	0.09
	Posterior tilt – lateral tilt pelvic	5.41	3.55	0.13
Soresen	Without tilt – anterior tilt pelvic	9.50	3.74	0.01*
	Without tilt – posterior tilt pelvic	10.50	3.74	0.007*
	Without tilt – lateral tilt pelvic	1.50	3.74	0.051
	Anterior tilt – posterior tilt pelvic	1.10	3.74	0.77
	Anterior tilt – lateral tilt pelvic	2.00	3.74	0.59
	Posterior tilt – lateral tilt pelvic	-3.10	3.74	0.40
Abdominal plank	Without tilt – anterior tilt pelvic	5.25	2.19	0.02*
	Without tilt – posterior tilt pelvic	7.50	2.19	0.001*
	Without tilt – lateral tilt pelvic	6.08	2.19	0.008*
	Anterior tilt – posterior tilt pelvic	2.25	2.19	0.31
	Anterior tilt – lateral tilt pelvic	0.83	2.19	0.70
	Posterior tilt – lateral tilt pelvic	-1.41	2.19	0.52
Right plank	Without tilt – anterior tilt pelvic	10.33	3.07	0.002*
	Without tilt – posterior tilt pelvic	15.00	3.07	0.001*
	Without tilt – lateral tilt pelvic	17.58	3.07	0.001*
	Anterior tilt – posterior tilt pelvic	4.66	3.07	0.13
	Anterior tilt – lateral tilt pelvic	7.25	3.07	0.02*
	Posterior tilt – lateral tilt pelvic	2.58	3.07	0.40
Left plank	Without tilt – anterior tilt pelvic	9.83	2.81	0.001*
	Without tilt – posterior tilt pelvic	12.08	2.81	0.001*
	Without tilt – lateral tilt pelvic	17.16	2.81	0.001*
	Anterior tilt – posterior tilt pelvic	2.25	2.81	0.42
	Anterior tilt – lateral tilt pelvic	7.33	2.81	0.01*
	Posterior tilt – lateral tilt pelvic	5.08	2.81	0.07
Score of core endurance	Without tilt – anterior tilt pelvic	8.30	1.48	0.001*
	Without tilt – posterior tilt pelvic	10.46	1.48	0.001*
	Without tilt – lateral tilt pelvic	12.18	1.48	0.001*
	Anterior tilt – posterior tilt pelvic	2.16	1.48	0.15

	Anterior tilt – lateral tilt pelvic	3.88	1.48	0.01*
	Posterior tilt – lateral tilt pelvic	1.71	1.48	0.25
Single – leg squat	Without tilt – anterior tilt pelvic	5.16	0.71	0.001*
	Without tilt – posterior tilt pelvic	4.75	0.71	0.001*
	Without tilt – lateral tilt pelvic	8.25	0.71	0.001*
	Anterior tilt – posterior tilt pelvic	-0.41	0.71	0.56
	Anterior tilt – lateral tilt pelvic	3.08	0.71	0.001*
	Posterior tilt – lateral tilt pelvic	3.50	0.71	0.001*

* Indicates a statistically significant difference between groups (P≤0/05).

The results of Table 3 showed that in 60 degree flexion test, abdominal plank, between without and tilted subjects, in the Sorensen test between without subjects and anterior and posterior tilt, in right and left plank test between without and tilted There is a significant difference between different subjects as well as individuals with anterior tilt and lateral tilt. Therefore, there is a significant difference in core endurance test except for anterior tilt-posterior tilt of pelvic and posterior tilt-lateral tilt and in the SLST except for anterior tilt-posterior tilt groups in other groups.

4. DISCUSSION

As stated, the purpose of the present study is to compare the functional test scores associated with non-contact lower extremity injuries and core endurance in subjects with and without PT. The results of the study showed a significant difference between core endurance tests and single leg squat tests that are associated with lower extremity injury, which indicates an increased risk of lower extremity injury with abnormal pelvic angle changes. To justify this, research results show that anterior PT increases hip flexion and internal rotation, which weakens the hamstring and alters torque arm, and a team of researchers found Pelvic tilt anterior has a significant predictive relationship with lower extremity injury, especially ligament injury it has an anterior cross (Hertel et al., 2004). Core muscle weakness or imbalance can lead to compensatory movement strategies that can eventually lead to injury (Willardson, 2014).

Since the stability and proper positioning of the core anatomy causes strong and effective movement of the upper and lower extremities, it seems that the fit between the muscle groups is of great importance and changes in their proportions can affect changes in it has hip angles (Nouillot et al., 1992). Under normal conditions, the anterior superior iliac spine to the posterior superior iliac spine and the two anterior superior spines to certain angles have weak muscles such as the anterior abdominal and dorsal muscles, as well as flexor and extensor muscles of the pelvic, and change these angles, and since changes in pelvic angles are known to cause anterior cruciate ligament injury, trunk muscle weakness appears to be due to the pelvic angle or pelvic angle changes followed by core muscle weakness can facilitate increased risk of ACL injury (Saki et al., 2013).

In a similar study, a group researchers investigated the relationship between the strength of the abductor and adductor hip muscles with the knee ACL ligament rupture in soccer men (Khani et al., 2013). It was found that in the healthy group, these muscles had greater strength than the ligament rupture group and assumed that their weakness could be effective in unilaterally increasing PT and subsequently producing lateral tilt (Khani et al., 2013). The lateral PT appears to be due to the problem of external rotary and abductor hip muscles known as core muscles, ACL injury is a factor. On the other hand, the results of different researches on the effect of core stabilization exercise on lowering the risk of lower extremity injury, especially ACL, can show the difference of this injury in the two groups with weak and strong core stability, showed that core muscle training improves landing kinetics and may reduce the risk of lower extremity injury in female athletes (Arjo et al., 2015).

Overall, it can be concluded that imbalances in the strength of different parts of the core region can lead to changes in the pelvic area and also weakness of these muscles can increase the risk of injury because the core part in the proper movement and force of the upper extremity to lower extremity and vice versa, thus important in initiating movement. No research has been found to justify the poor performance of people with different PT compared to healthy subjects, but theoretically we can say that changes such as anterior PT by the association with changes muscles are capable of making a difference in performance, For example, anterior PT resulted in increased lordosis, which may result in weakness of the anterior abdominal and posterior thigh muscles and shortening of the lumbar extensor and hip flexor muscles, which may affect performance. In the case of posterior PT, this situation was reversed as there was shortness in the pair of anterior abdominal and posterior thigh muscles and weakness in the pair of lumbar extensor and hip flexor muscles. Some studies also point to the relationship between PT changes, and changes in muscle length, in one study on cyclists noted the association between hamstring shortening and anterior PT. (Muyor et al., 2011). Due to the fact that the greater end of the pelvic floor muscles, which affect the tilt and angle, cross the knee area and affect its position and function, it is expected that the changes in strength and length of these muscles can be expected. It can affect the performance of the area and its ability to deal with dangerous situations such as injury.

For example, quadriceps muscle contraction exerts an anterior shear force when the femur-tibia joint is near full extension, thus increasing stress on the ACL (Levanagie and Norkin, 2011). In addition to affecting function, it can increase the risk of injury to this ligament. Differences between healthy subjects and those with different PT were also found in the single leg Squat tests as predictors of injury that performance differences could be attributed to changes in strength and balance of muscle ratio and increased risk. Anterior cruciate ligament injury can be due to the fact that in these conditions, the abductor muscles and the extensor muscles lose their function and there is no control over the pelvic and thigh and the anti-gravity muscles that put the upright, due to muscle weakness and loss of mechanical efficiency they cannot perform well (Ireland, 1999). Overall, in justifying the results comparing performance and balance in the four groups, it can be expected that pelvic changes due to the chain communication of this region with the knee and lower extremity can lead to the risk of injury in this area.

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CONFLICT OF INTEREST

The authors have no conflict of interests.

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