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Research Article

The Effects of Preparation on Knee Frontal Plane Projection Angle During Landing Tasks in Female Athletes: A Study Protocol

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Abstract: Landing after the jump is a high risk mechanism that can be followed by numerous injuries of the lower extremity, especially in the knee. Lower limb injuries often are created in a condition that the person is not able to prepare for possible injury. Some studies have shown that appropriate and effective preparation during landing can reduce the injury risk. The present study aims to evaluate the effects of preparation on knee frontal plane projection angle (KFPPA) during landing tasks among the female athletes. In this cross-sectional study, 22 female recreational athletic activities will be selected using non-random sampling and measured KFPPA during the diverse landing tasks. Furthermore, all subjects will perform four common screening tasks as follows: the double leg drop landing and single leg drop landing for tasks with preparation; double leg jump landing and single leg jump landing for tasks without preparation. Several studies indirectly have investigated the influence of preparation on biomechanical factors of the lower extremity but direct impact of preparation has not been into consideration. Accordingly, the present study protocol will evaluate direct influence on the KFPPA during the landing in the recreational female athletes.
Keywords: Landing, Preparation, Knee frontal plane projection angle

INTRODUCTION

Landing is a high demand activity that can be seen in a lot of different forms of sports [1]. During the activities of the landing, forces and torques are produced by the muscle tendon unit and reaction forces and exerted to the lower limb musculoskeletal structures that because of the high demand of this activity, the probability of injury of these structures in the lower extremity is high [2, 3]. For preventing the injury while landing, the body must have the ability to respond to stress and can maintain its balance. Control of torques produced and maintaining the balance while landing should be made by all the joints of the lower extremities and for this reason an important challenge can be created in neuromuscular system before and during landing [4].

A successful function in a landing task will require an appropriate and effective interaction between persons with the landing surface to obtain the desired goal during the activity. Forces imported to the musculoskeletal system during landing depend on how an interaction person with the landing surface [4]. Landing can import the forces equal to 2 up to 12 times the body weight to the lower extremity [5, 6]. The evidence shows that a person can voluntarily adjust the external loads up to 8 times the body weight during contact with the ground, by employing multi joint strategy by central nervous system (CNS). Landing strategy chosen by the athlete represents a person's preference for distributing internal forces between the bones, joints and single or double joint muscles. The difference between athletes in the control strategies depends on physiological and morphological features and motor control that are determined based on the particular condition, the velocity and surface activity [4]. After contact with the ground while landing suddenly a large force is imported into the musculoskeletal system; therefore, for absorbing and distributing forces and controlling reaction forces, prior to contact with the ground, based on existing patterns in the brain and by the feed forward mechanism an appropriate strategy must be applied that it can be referred to as preparation [7]. In other words, dynamic and ongoing preparation for collecting data and their analysis in the CNS and detection of critical functions to prevent damage and guidance information needed for activities directed to the related joints and muscles is with the use of preset patterns in the brain [8]. A person's ability to the preparation can be determined with help of vision, preparation time and kinematic of segments before contact with the ground. How to prepare a person for contact with the ground affects the distribution of the reaction forces during landing [4].

A longer flight time in landing leads to a stronger and a better preparation occurrence and why is it that a longer flight time gives more opportunities to system to select the position of joints and muscles to be able to do well in distributing and absorbing the force during landing. It is said that one of the reasons that women with the less flexion status of lower limb joints do the landing is that their flight time is less than men, and this can cause the more injury risk in their lower extremity [4]. It seems that the vision will have an important role in the preparation so that when the flight time decreases, the opportunity to look at the level decreases as well and as a result preparation gets disrupted [4]. Knee damage during landing can be caused by biomechanical factors and bad technique of the athlete. According to Some researchers, the most important factor among biomechanical risk factors, is the knee valgus angle that as a result as increasing this angle the risk of injury in knee increases [9-13]. Bad technical people land with erect position i.e. while landing they use less flexion in the hip and knee and this makes the knee valgus angle during landing at these people gets more and the risk of knee injury increases [14-17]. Since the landing is a dynamic activity, in some cases during this activity an abnormal dynamic knee valgus is created for a person which causes a reduction in the knee flexion, an increase in the knee valgus loads, and an increase in the hip adduction & internal rotation [18, 19]. For this reason the risk of knee injury during landing despite abnormal dynamic knee valgus increases. That is why knee injury risk is greater in the women, too [10, 12, 18]. It is said that since women do landing with a less flexion of the joints of the lower extremities a more dynamic knee valgus is created for them compared to the men and this makes the risk of injury in the lower extremities in the woman more [9, 13].

Munro and Herington indicated that feedback given to the person leads to a reduction in the vertical ground reaction force (VGRF) and in the amount of Knee frontal plane projection angle (KFPPA) at a drop Jump Landing task that may help to reduce the risk of knee injury [20]. Also, Clare et al. showed that, in a jump-landing task, verbal commands caused a reduction in VGRF and KFPPA and an increase in flexion of the knees while landing that may help a reduction in the risk of knee injury [14]. Hagin *et al*. showed that the landing in inclined floor conditions increases biomechanical variables of the knee, including knee valgus angle and VGRF, which causes the damage [21]. In another study Cortes et al. investigated the effects of two landing techniques (forefoot and rearfoot) in the lower limb biomechanics during two unanticipated tasks (pivoting & side step cutting) in professional footballers and concluded that different techniques for landing during the unanticipated activities, which normally happens in sports, can change the biomechanical variables of lower extremity (knee valgus angle, hip adduction, knee flexion, and GRF) [22].

Considering that the problems of the lower limbs often occur when an individual is in terms of damage and is not prepared to deal with an injury, and given that in the studies referenced above, no study exists that investigate directly the influence of preparation on the biomechanical factors of lower extremity, therefore, the present study protocol will investigate the direct influence of the preparation during the landing. So this study will try to investigate the KFPPA during landing with preparation and without preparation in female athletes.

MATERIALS AND METHODS

Participants

This cross sectional study will evaluate preparation effects on KFPPA during landing tasks among female athletes. The inclusion criteria will be female recreational athletic activities with age 20-30 years and body mass index (BMI) between 22 and 25 kg/m2. History of orthopedic and neurological disorders in the past six months, the use of any substances that affect postural control in the 48 hours prior to tests and pregnant female will be excluded from the study.

The study protocol has been approved by Tehran University of Medical Sciences Ethics Committee, and before the testing, all subjects will be informed of the purpose and the procedure of the study and will sign an informed consent form

Sampling Method

A convenience sampling method will be used to select 20-30-year-old female athletes from Tehran University of Medical Sciences (Tehran, Iran). The sample size was calculated as 22 considering type I error of α=0.05, and type II error of β=0.2, and power=0.8(23). The values of δ_1, δ_2, μ_1, and μ_2 were obtained from a pilot study of five individuals from each group (with preparation and without preparation). The following equation was used to determine sample size:

$$n= \frac{(Z_{1-\alpha/2}+Z_{1-\beta})^2(\delta_1^2+\delta_2^2)}{(\mu_1-\mu_2)^2}$$

Data Collection

Pilot Study

To evaluate the intra-rater reliability of all dependent and independent variables in the methodological study, 10 subjects will be selected. They will undergo all stages of the test in two sessions and each session includes three trials in a single day and with an hour interval. If the statistical tests confirm the reliability of the tests, the main study will be initiated.

All the testing procedures will be conducted by an examiner.

Main Study

The participants will be asked to wear shorts and laboratory footwear. The researchers will place markers on the lower extremity of each subject [19, 24]. The markers will be placed at the midpoint of the femoral condyles to approximate the center of the knee joint, midpoint of the ankle malleoli for the center of the ankle joint, on the proximal thigh at the midpoint along a line from the anterior superior iliac spine to the knee marker, on the tibial tuberosity and on the anterior superior iliac spine. By using a standard tape measure the midpoints will be determined and the same experimenter will place all markers. In order to determine KFPPA by a 3-dimensional motion analyzer these markers will be used. (Qualisys co, Sweden, resolution 1.3 megapixels and speed of 500 frames per second). The researchers can find further information on this process later in the method. At the start of each test the person adopts a fixed situation to reach the body into a stable state. In this case a static record of people will be done. four common screening tasks, including the double leg drop landing, single leg drop landing [25], double leg jump landing and single leg jump landing will be performed by all subjects [14]. All participants will have an opportunity to practice the tasks until they are comfortable; this will be contain usually one to two practice trials. After that, for each task the subjects will perform three test trials; according to the block order the sequence of tasks will be assigned and in each task the dominant leg will be tested and analyzed.

KFPPA processing

The KFPPA will be measured as the angle subtended between the line from the markers on the proximal thigh to the knee joint and the line from the knee joint to the ankle. Also, it will be measured in a frame which corresponds with the point of maximum knee flexion. As the lowest point of the movement the point of maximum knee flexion will be determined. The same experimenter will digitize each angle manually using the Qualisys software. Positive values of KFPPA reflect knee valgus, excursion of the knee towards the midline of the body; consequently the knee marker is placed on the medial side of a line between the ankle and thigh markers. On the other hand, negative values of KFPPA reflect knee varus, the average KFPPA from three trials will be used for doing an analysis [19, 24]. By using intraclass correlation coefficients and range from 0.72 to 0.91, between-session reliability of this method has been confirmed [26].

Screening tasks

- Double leg drop landing task: A subject standing on a staircase with a height of 28cm (The height of the shoes will be considered 2 cm) opens *the* legs shoulder width apart. The subject is leaning forward and with a maximum jump of 30 cm on the stairs that is marked, lands vertically with two feet.
- Single leg drop landing task: A subject standing on a staircase with a height of 28cm (The height of the shoes will be considered 2 cm) opens *the* legs shoulder width apart. The subject is leaning forward and with a maximum jump on a distance of 30 cm from the stairs that is marked, lands vertically with a foot, while he or she will raise the other leg to prevent a contact with the surface.
- Double leg jump landing task: A subject standing on the ground and opens the legs shoulder width apart. By two legs the subject jumps vertically upward while hands must be up to the highest possible point, and then he or she will land with two feet.
- Single leg jump landing: A subject standing on the ground and opens the legs shoulder width apart. By two legs the subject jumps vertically upward while hands must be up to the highest possible point, and then he or she will land with one foot.

Data Analysis

Descriptive statistical methods, including dispersion and central tendency, will be adopted to describe the variables. One-Sample Kolmogorov-Smirnov Test will be applied to check normal distribution of data. Paired Sample T test will be utilized for multiple comparisons of the groups. The reliability of the results will be assessed through intra-class correlation coefficient, standard error of measurement, and minimal detectable change. Type I error will be considered at the *0.05* level.

DISCUSSION

There are several studies that have investigated indirectly the preparation effect on the biomechanical factors of the lower extremity. The findings of these studies can show that an appropriate and effective preparation during landing can reduce the risk of injury and an impairment of preparation, and in other words, the inability of the person in preparation of landing surface increases the knee injury risk. Given that the majority of lower limb problems occurs when an individual is in terms of damage and is not prepared to create the lesion. In none of the studies cited in the text, the direct impact of the preparation has been taken into consideration. In the present study, the direct impact of the preparation on KFPPA during the landing in the female recreational athletes. In other words, in this study, we will compare the amount of the KFPPA during different landing tasks (with and without preparation). These tasks are designed in such a way that in a task a person is able for preparation of landing position and in another task a person is not able for preparation in landing position. The study can be a starting point for future studies concerning the landing in order to obtain strategies for preventing the injury and the knee injury risk reduction.

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