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Original article

Lower extremity injury in female basketball players is related to a large difference in peak eversion torque between barefoot and shod conditions

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Abstract

Background: The majority of injuries reported in female basketball players are ankle sprains and mechanisms leading to injury have been debated. Investigations into muscular imbalances in barefoot versus shod conditions and their relationship with injury severity have not been performed. The purpose of this study was to investigate the effects of wearing athletic shoes on muscular strength and its relationship to lower extremity injuries, specifically female basketball players due to the high incidence of ankle injuries in this population.
Methods: During pre-season, 11 female collegiate basketball players underwent inversion and eversion muscle strength testing using an isokinetic dynamometer in both a barefoot and shod conditions. The difference between conditions was calculated for inversion and eversion peak torque, time to peak torque as well as eversion-to-inversion peak torque percent strength ratio for both conditions. Lower extremity injuries were documented and ranked in severity. The ranked difference between barefoot and shod conditions for peak torque and time to peak torque as well as percent strength ratio was correlated with injury ranking using a Spearman rho correlation (ρ) with an α level of 0.05.
Results: The ranked differences in barefoot and shod for peak eversion and inversion torque at 120°/s were correlated with their injury ranking. Ranking of the athletes based on the severity of injuries that were sustained during the season was found to have a strong, positive relationship with the difference in peak eversion torque between barefoot and shod ($\rho = 0.78$; $p = 0.02$).
Conclusion: It is possible that a large discrepancy between strength in barefoot and shod conditions can predispose an athlete to injury. Narrowing the difference in peak eversion torque between barefoot and shod could decrease propensity to injury. Future work should investigate the effect of restoration of muscular strength during barefoot and shod exercise on injury rates.
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Keywords: Ankle sprain; Isokinetic dynamometer; Muscular imbalance; Strength

1. Introduction

More than 60% of all college women's basketball injuries occur in the lower extremities.[1] Over a 16-year period, 24.6% of these injuries were due to ankle ligament sprains during games and practices. Ankle ligament sprains were the second ranked injury leading to 10 or more days of activity loss, with knee internal derangement being the first leading cause.[1] Furthermore, a history of ankle sprains would leave a player five times more likely to sustain another ankle injury.[1] The incidence of injury in female high school basketball players

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demonstrates a similar pattern, with ankle sprains as the leading injury sustained.[2]

Several investigations into the primary etiology of ankle sprains have been conducted to probe the biomechanical mechanisms that may be responsible for the high incidence of ankle ligament sprains in female basketball players. Baumhauer et al.[3] concluded that eversion-to-inversion strength ratio was a predictive measure of ankle injury. This finding has not been consistently supported, as these results have not been clearly replicated.[4,5] Hence, several other measures have been evaluated including ankle strength,[4-7] postural sway,[6,7] proprioception,[5] shoe height,[8,9] and peroneal reaction time.[10,11] Fong et al.[12] recently listed the two main causes to ankle sprains as improper foot positioning during heel strike and delayed reaction time of the peroneal musculature. Even still, the etiology of ankle sprains has yet to be clearly defined.

There is strong evidence that shoes can control the motion and position of the foot and provide cushion.[13−16] However, despite the advances in shoe construction, lower extremity injuries are still being reported in large numbers.[1] Prevention of injury may be dependent on intrinsic muscular strength of the ankle complex. In terms of foot and ankle musculature, the tibialis anterior (invertor) and triceps surae could be considered as larger muscles, that are most responsive to movement in the sagittal plane and not as responsive to movement in the frontal plane.[17] Smaller musculature about the ankle and foot provide stability quickly and easily to the ankle joint complex by reacting faster to joint movement changes.[17] Nigg[18] has demonstrated that increased strength in these smaller, intrinsic muscles may lead to improved performance and protection, while the opposite can also be true. Therefore the strength of these smaller, intrinsic muscles may have an important relationship with susceptibility to lower extremity injury.

Avoidance of excessive movement about the ankle is provided by the ankle musculature, but only if the musculature is properly activated. This is especially true for smaller intrinsic muscles which provide stability to the ankle joint complex by reacting faster to joint movement changes.[17,18] Essentially, deconditioned musculature may not only cause a decrease in the force production to control excessive subtalar motion, but also may delay neuromuscular responses.[11] Support for this notion has been demonstrated when soccer and cross-country runners with and without ankle instability were tested for central and peripheral reaction times. It was found that players with severe ankle instability demonstrated peripheral latency of peroneal muscles.[11] When activated, the ankle and foot musculature take considerable milliseconds (i.e., 92−133 ms) after the latency period before maximal muscular strength can be developed.[8] It is possible that deconditioning or atrophy of the muscular structure of the foot and ankle would cause a delay in peripheral reaction, leading to increased latency response of muscle activation and eventually a decrease in the ability to quickly generate force.[19,20] It has also been suggested that decreased sensations provided by wearing shoes may promote the skeletal musculature of the foot and ankle to become deconditioned.[21] This is not to say that if a shoe provides artificial strength, that barefoot play is recommended, rather the goal is to identify a testing method that will allow for identification of athletes predisposed for injury.

Therefore, the purpose of this study was to investigate the effects of wearing athletic shoes on muscular strength and its relationship to lower extremity injuries, specifically female basketball players due to the high incidence of ankle injuries in this population. It was hypothesized that individuals that demonstrated similar ankle eversion strength between barefoot and shod conditions would be less susceptible to injury. Ankle evertor musculature provides support and functions as a dynamic stabilizer of the ankle against inversion; thus playing an important role in preventing inversion ankle sprains and/or lower extremity injury. In order to test this hypothesis, ankle inversion and eversion peak torque in both barefoot and shod conditions was measured prior to a college basketball season. Injuries were then measured prospectively and were recorded throughout the season. At the end of the season, athletic trainers ranked the athletes in terms of injury severity. Ranked differences in peak torque of the athletes were then correlated with ranked injury severity. Thus, a unique feature of this study is its prospective nature and such studies are scarce in the literature.

2. Methods

Eleven female basketball players (age: 20.4 ± 3.2 years; height: 172.0 ± 7.6 cm; mass: 73.5 ± 15.9 kg) from the University of Nebraska at Omaha were consented and participated in the study. The participants were healthy and free from any present musculoskeletal injury. All testing was conducted during the basketball pre-season. All procedures were approved by the University's Institutional Review Board.

Prior to testing, subjects warmed up on a Monarch stationary bicycle at a self-selected pace and resistance for a minimum of 10 min. Eversion and inversion muscular strength when barefoot (barefoot condition) and while wearing their own high-top, basketball shoes (shod condition) were recorded using an isokinetic dynamometer (Biodex System 2.0; Biodex Medical Systems, Shirley, New York, USA). The subjects wore their own shoes to minimize any shoe-type effect by introducing discomfort or lack of adaptability due to the usage of a new shoe. Each subject was seated, with the trunk, thigh, and shank secured. Standard positioning for the ankle inversion and eversion testing was used according to the manufacturer's guidelines. Subjects were seated and their right leg was raised so that the shank was perpendicular to the footplate attachment. With the shank supported, the right foot was secured into the footplate in neutral position and zero degrees plantarflexion. Isokinetic testing of the right ankle was administered at 120°/s within a comfortable range of motion (mean ± SD) for barefoot condition (76.8° ± 12.1°) and shod condition (71.1° ± 16.7°). Three maximal repetitions were performed. A minimum of 24 h of rest was required before the subject returned to undergo testing under the second condition. Presentation of barefoot and shod conditions was randomized between subjects. Prior to each recorded performance, the

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