

GENDER DIFFERENCES IN TIBIAL ACCELERATION IN PRE-SEASON YOUTH SOCCER PLAYERS

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In soccer, the players need to be able to change direction quickly, meaning the players need the ability to rapidly accelerate and decelerate. Females at a young age have a higher risk of sustaining injuries that can be caused by rapidly accelerating compared to males. The purpose was to investigate the gender differences in acceleration in youth soccer players. 30 youth soccer players engaged in the following drills: a jog, the M drill, 5-10-5 drill, and a single leg triple jump. This data was collected using inertial measurement units. The peak accelerations in the M drill on the left side was the only statistically significant drill ($p=0.006$, females: $590.9 \pm 275.9 \text{ m/s}^2$, males: $882.1 \pm 263.4 \text{ m/s}^2$). There is support to add load management strategies to current training programs and that individualized programs may be the most effective.

KEYWORDS: acceleration, soccer, gender

INTRODUCTION: As of 2014, there were more than 3 million youth soccer players registered in the United States of America, with 48% of those individuals being female (Watson et al., 2019). In soccer (football) the ability of a player to change directions through rapidly accelerating and decelerating is related to the athlete's overall performance and competitiveness (Mendez-Villanueva et al., 2011). To improve performance and reduce the rate of injuries the effect of acceleration on performance and effects it has on injury rates should be further examined. Anterior cruciate ligament (ACL) injuries are common and tend to occur during movement patterns involving rapid acceleration and deceleration and changes in direction (De Ste Croix et al., 2015). Previous research has found that females have 2-3 times the risk of sustaining an ACL injury compared to male soccer players and that females are more likely to sustain the injury at a younger age compared to males (Waldèn et al., 2011). This increased risk of sustaining an ACL injury for female soccer players is related to factors such as the neuromuscular activation patterns, the anatomy of the lower extremity, and the effects from hormones (Watson et al., 2019). Therefore, it is important to examine the effect of gender at a young age on acceleration in soccer. Overuse injuries of the lower extremities also occur in soccer players. For youth soccer players the most common are tendinitis, patellofemoral pain, and Osgood-Schlatter disease (O'Kane et al., 2017). Patellar tendonitis is caused by repeatedly overloading the knee extensor mechanism and can be treated, however recurring symptoms may occur (Patterson, 2009). The chronic traction injuries that are most reported in soccer involve the pelvis and lower extremities with the most common being an avulsion fracture of the ischial tuberosity (Patterson, 2009). These injuries are chronic when repetitive traction, which is pulling on the fractured body segment, occurs and often heal when new bone forms (Patterson, 2009). Sever's disease (calcaneal apophysitis) is caused by limited flexibility of the Achilles tendon which can cause abnormal stress during running due to repetitive heel-loading and can be treated but the symptoms of the condition may not go away until the growth plate matures and fuses (Patterson, 2009). These chronic conditions that can occur as a result of playing youth soccer is another reason gender differences should be examined in acceleration and acceleration integrals to develop a better understanding of the factors that should be considered to reduce the risk of injuries and develop training interventions. The peak acceleration is defined as maximum load on the athlete's tibia. The acceleration integral is defined as the cumulative loading on the athlete's tibia across the trial. The load placed on the athlete can be external or internal and acceleration is an external load measurement of the work the athlete is doing (Sniffen et al., 2022). According to a systematic review, 79% of the studies showed a positive relationship between cumulative load, measured by GPS, and injuries in youth soccer (Sniffen et al., 2022). One study utilizing GPS systems found that the injury risk for elite

youth soccer players was highest when there was a very high number (≥ 9254) of accelerations performed over a 3-week period and that the total external load based on acceleration over a 1-week period significantly increased the overall and non-contact injury risk (Bowen et al., 2016). Previous research shows there is a connection between acceleration, an external load, and injuries in youth soccer, therefore this connection within sport-specific drills should be further examined. Previous research utilized GPS systems, whereas this research examined acceleration metrics using IMUs, which has not previously been done before and therefore addresses a gap in the literature. The purpose of this project was to examine youth soccer players for the gender differences in peak tibial accelerations and acceleration integrals.

METHODS: 30 youth soccer players (15 female, 15 male) voluntarily participated within this study and were recruited from a local soccer program. Participants were in a similar age range (average age: 9.6 ± 0.4 years old for males, 9.6 ± 0.6 years old for females) to eliminate confounding variables. The athletes completed assent forms and the athlete's parents filled out the informed consent form, Lower Extremity Functional Scale, and a musculoskeletal injury history questionnaire. Inertial measurement units (IMUs) (1600 Hz; Vicon Blue Trident, Vicon Motion Systems Ltd, Oxford, UK) were rigidly attached to the participants distal-medial tibia and slightly superior to the medial malleolus of both legs. Participants engaged in agility and jumping drills. The first drill was a 36.6-meter jog in which the participants jogged down and back. The second drill was a M-cone drill in which the participants sprinted around the cones changing direction rapidly. This drill was completed in both directions so that the load was primarily placed on the right and then left leg. In the third drill, a 5-10-5-meter lateral shuffle drill, participants shuffled 5 meters, changed directions and shuffled 10 meters, and then shuffled 5 meters back. The final drill was a single leg triple jump in which the participants goal was maximum horizontal displacement. The 3D linear acceleration data was analyzed using Python v3.10.4 (Python Software Foundation, Beaverton, OR, USA). Statistical significance was determined using an independent t-test ($\alpha=0.05$) using R 4.2.1 (R Foundation for Statistical Computing, Vienna, AUST).

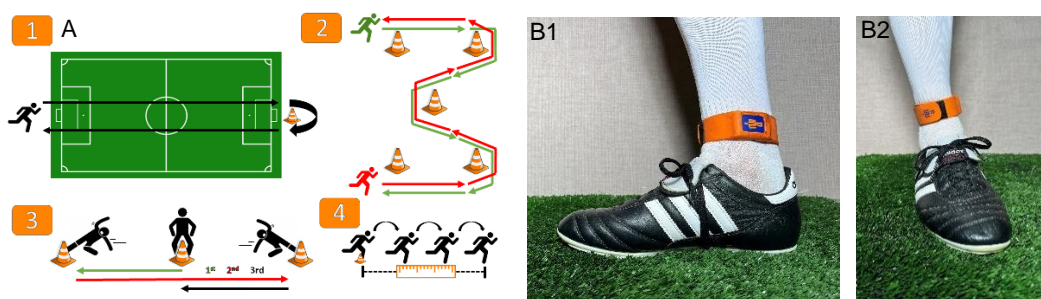


Figure 1: A) Diagram of the agility and jumping drills B) Visual representation of how the IMUs were attached with silicon straps and Velcro around the distal lower extremity (1. Sagittal plane, 2. Frontal plane).

RESULTS: The gender comparison of peak accelerations of the participants can be found in Figure 2. There was a significant gender difference in peak accelerations (Figure 2A) during the M-cone drill left ($p=0.006$) as females exhibited a peak acceleration of 590.9 ± 275.9 m/s^2 compared to 882.1 ± 263.4 m/s^2 for males. The peak accelerations were not significantly different between genders for the down and back jog ($p=0.795$), 5-10-5 drill ($p=0.500$), M-cone drill right ($p=0.615$), triple hop left ($p=0.381$), or triple hop right ($p=0.943$). The acceleration integrals (Figure 2B) were not statistically different between boys and girls for the down and back jog ($p=0.744$), 5-10-5 drill ($p=0.963$), M-cone drill left ($p=0.393$), M-cone drill right ($p=0.333$), triple hop left ($p=0.477$), or triple hop right ($p=0.154$). The cumulative loading is noticeably smaller for the single leg triple jumps compared to the other drills. For the single leg triple jump on the right leg there is more extreme outliers for the males compared the females.

DISCUSSION: When decelerating, females tend to have more internal hip rotation and external tibia rotation (Voskianian, 2013). Females usually have a higher quadriceps activation as well as differences, in comparison to males, in the recruitment, timing, and strength of muscles, which seem to be a risk factor for an ACL injury (Watson et al., 2019). These biomechanical risk factors for ACL injuries may be modifiable and previous research has examined if teaching the athletes the proper skills to land and decelerate were an effective method. One intervention program, that included 3 soccer specific agility drills, found a 74-88% ACL injury reduction (Mandelbaum et al., 2005).

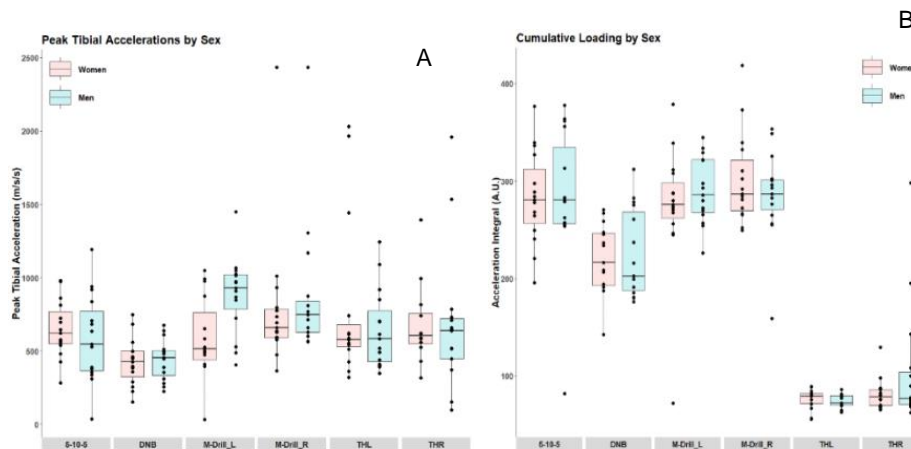


Figure 2: A) Comparison of gender differences in peak accelerations (Mean \pm Standard Deviation). B) Comparison of the gender differences of the acceleration integrals over the trial (Mean \pm Standard Deviation).

One systematic review found that 79% of the studies found a positive relationship between cumulative load and injuries in youth soccer (Sniffen et al, 2022). This systematic review found that many of the current training interventions for injury prevention are neuromuscular training programs, but that there was also support for supplementary training interventions with load management strategies (Sniffen et al., 2022). The cumulative loading of the tibia is noticeably smaller in the single leg triple jump for both the right and left legs compared to the other drills. Drill selection may be a factor to consider when developing training interventions and the cumulative load of each activity within the training session.

Puberty, in terms of physiological growth, begins in females from the age of 8-13 years old and does not begin in males until the age of 9-14 years old (Farello et al., 2019). The average age for females in this research was 9.573 ± 0.605 years old and 9.601 ± 0.445 years old for males. Since the participants of this research were on the younger end of the beginning of puberty, this may not have allowed for an adequate amount of time for the associated physiological changes to occur and present in the participants measured movements. These results thus far show that further research should be done on a larger pool of participants and that the comparison of gender differences should be examined both during puberty and post-puberty to investigate how these differences change. This future research may help to develop more individualized and successful training programs for each gender and age group.

CONCLUSION: The results of this subset of participants from the pilot program showed statistical significance in the peak acceleration of the M-cone drill with a loading emphasis on the left lower extremity where males had a higher average peak compared to females. While future research needs to occur, this research can be applied by sports medicine professionals and coaches when developing injury prevention training intervention programs for youth soccer teams. Suggested ways that manage load include decreasing the total training session per week or reducing the number of hours participating in sports (Sniffen et al, 2022). However, practitioners and coaches

should be careful in developing these intervention programs that athletes are being properly prepared for the demands of competition and decreased training loads may not be adequate and thus individualized programs would be more appropriate (Jayanthi et al., 2021).

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