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Is There a Relationship Between Foot Reaction Time and Ankle Frontal Plane Torque in Female Soccer Athletes? A Pilot Study

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ABSTRACT

International Journal of Exercise Science 15(1): 1506-1513, 2022. The purpose of this study was to determine if a relationship existed between foot reaction time and ankle frontal plane peak torque in female soccer athletes. A one-shot case study design was selected for this investigation. Seventeen female college athletes volunteered to participate. Right and left foot reaction time measurements were assessed using 3x4 switch mats interfaced with a precise timing counter. Participants stood in front of the mat with eyes closed and responded to the auditory stimulus by touching the mat as fast as possible with their foot. Two trials were conducted per foot, and the best time was used to determine the reaction time score per foot. An isokinetic dynamometer assessed inversion and eversion peak torque for both right and left ankle joint at 120°/sec. Left peak torque eversion and right foot reaction time demonstrated a significant negative moderate relationship (r = -0.530; p value = 0.03). Left ankle peak torque eversion does have a significant moderate negative relationship to reaction time of the right foot; therefore, evasive dribbling movements which requires inversion and eversion torque could directly affect foot reaction time, resulting in improved dribbling performance for soccer athletes.

KEY WORDS: Ankle inversion, ankle eversion, slalom dribbling, women athletes

INTRODUCTION

Soccer places high biomechanical demands upon lower extremity joints, especially when creating explosive action through kicking, challenging, tackling the ball, among other movements (8, 13). While previous biomechanical soccer investigations have largely focused on the knee and hip, the ankle joint has received limited attention, especially with regards to the support leg that allows for the soccer-related movements such as slalom dribbling or evading (1, 13, 15).

Dribbling in soccer is known to require great skill development (21, 23). During this action, the side of the foot is often used to maneuver the ball around opponents known as slalom dribbling compared to using the instep (8, 12, 17). Slalom dribbling requires the left subtalar joint to be at an outward angle (i.e., ankle eversion) to control ball direction towards the right (7, 8). The ability to control and direct the ball towards the left requires the subtalar joint to be positioned inwardly (i.e., ankle inversion). The speed of the foot during a side-foot pass or a deliberate ball movement around objects/opponents is less than an instep kick (15). This leads to a greater ball-to-foot speed ratio and a relatively greater ball speed.

Although speed of the foot seems to be of great importance to maneuver the ball successfully in soccer, literature is scarce with regards to the understanding of the mechanisms involved with foot reaction time with soccer athletes. Given that environmental stimuli and task-specific reactive movements are constantly changing in a soccer match/practice, foot reaction time should be a critical component in this sport. Previous work has demonstrated that muscle reaction time was impacted by muscle weakness (14). More specifically, delayed reaction time was correlated with lower peak torque measures of quadriceps, hamstring, and gastrocnemius muscles during isokinetic testing. Considering that most soccer movements require ankle control in multiple directions (and not only plantar/dorsiflexion), knowledge about ankle frontal plane torques could provide novel information towards foot reaction time and guide future soccer training.

Our central research question was "does frontal plane ankle strength play a role in foot reaction time?" If so, the ability to generate greater torque of ankle eversion or inversion could provide an advantage for female soccer athletes on the field. Therefore, the purpose of this study was to determine if a relationship between ankle frontal plane peak torque and foot reaction time exists in female collegiate soccer athletes. We hypothesized that greater frontal plane torque at the ankle joint would be related with faster reaction time in female soccer athletes.

METHODS

Participants

A one-shot case study (4) was selected for the research design of this investigation. Seventeen collegiate women soccer athletes were recruited for this experiment (age 20.6 ± 1.2 years, height 163.75 ± 8.4 cm, mass 62.25 ± 10.16 kgs, BMI 20.9 ± 0.45). Each participant qualified by being a current female collegiate soccer athlete with no pre-existing health conditions or pre-existing injuries, especially in the lower extremity ankle region prior to the start of data collection. All athletes were right limb dominant, based on the health questionnaire given before data collection took place. Athletes were briefed on the risks of the research project before signing consent forms and the rights of the participants were protected. The study was approved by the University's Institutional Review Board. This research was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science (18). All participants followed all procedures in accordance with the ethical standards of the Helsinki Declaration and completed a brief personal history form regarding date of birth, dominant limb, height, and weight as well as verifying that no previous ankle injuries had occurred.

Protocol

Prior to testing, each instrument was calibrated according to manufacturer's guidelines. Reaction time assessments were performed first followed by strength tests based on metabolic costs of performing assessments to prevent fatigue (9).

Simple reaction time was assessed by using 3 x 4 switch mats (model 63515A) interfaced with a precise timing counter (model 54060A), measured to 0.001 seconds (Lafayette Instruments, Lafayette, IN). Both switch mats were placed in front of each subject as they stood in the athletic position stance. Participants kept their eyes closed and reacted to the auditory stimulus created by the researcher's foot hitting the start mat. The participant responded by striking the flat switch mat, which was placed in front of the foot, striking as fast as possible upon command. This placement was to mimic similar movements of each limb before an evasive dibble would be initiated in soccer play. Each participant had one practice trial to become familiar with the test procedures. Two trials were performed with the right foot and two trials with the left foot. The best (i.e., fastest) of the two trials was used to determine the athletes' reaction time for each foot.

In alignment with past literature (4), peak torque was measured using the Biodex III Isokinetic Dynamometer (Biodex Medical Systems, Shirley, NY) at 120°/sec. This velocity was selected because it allows for decreased risk of injury as well as increased reproducibility of the data (5). The participants were in a sitting position angled at 110 degrees while being tested with their knee at 30 degrees and the non-tested foot resting on the calibrated leg rest. An across the body strap and waist strap was used to secure the participant. A knee strap was also wrapped around the athlete's leg to stabilize the leg and allow the ankle to function without outside assistance from the knee. After the machine was set for each athlete's range of motion of the ankle, participants started each trial with inverting their ankle to begin the testing. Before the official test, each athlete participated in one practice round of 5 repetitions of inversion and eversion movements to become familiar with the machine and to aid in a specific neuromuscular warm-up. The athlete then performed 5 complete reps of inversion and eversion movements against a resistance of 120°/sec as quickly as possible. The variable peak torque was reported in foot pounds (lb-ft). Trial 1 was performed with the right foot and once 5 complete reps were completed, the ankle attachment was moved to accommodate the left ankle. This transition and rest period took about 2 minutes which replicated isokinetic testing previously performed by our researchers (19) to restore phosphagen levels before performing trial 2 with the left foot at 5 complete maximal reps, in lieu of other cited sources that recommend 3-5 minutes of recovery in-between sets (9).

Statistical Analysis

Descriptive statistics was used to describe the variables of interest. A Pearson Product Moment Correlation was used to determine if a relationship existed between left ankle peak torque, right ankle peak torque, left best reaction time, right best reaction time for the left and right feet. Given the pilot nature of this investigation, once a correlation was established, a linear regression was used to determine potential predictor of reaction time. Paired t-tests were used to observe if significant differences existed between the variables of interest. All statistical treatments were performed with SPSS (version 26; Armonk, NY) and an alpha level was set at 0.05. Effect size and observed power were calculated to provide foundational data for further similar work. Effect sizes interpretation was set as small for ≤ 0.2, medium for 0.5, and large for ≥ 0.8 (3).

RESULTS

Table 1 demonstrates the best values of left and right peak torque for ankle inversion and eversion in foot-pounds (lb-ft) as well as for best reaction time for each foot. P values, effect size, and observed power is also listed in this table. A significant (p = 0.03) negative moderate relationship between left eversion torque and best right foot reaction time (r = -0.53) was observed (Figure 1). Other correlational values were not significant (Table 2). A linear regression indicated that 53.3% of the variance observed in right foot reaction time could be significantly explained by left ankle eversion torque (R^2 = 0.284, $F_{(1,15)}$ = 5.9, p = 0.028), with the following equation:

$$\text{Right Foot Reaction Time} = 0.48 - 0.006*(\text{Left Ankle Eversion Torque})$$

Table 1. Results are mean (standard deviation, range) of variables of interest. Cohen's *d* effect sizes and observed power were also included to further quantify comparisons.

	Left	Right	*p*	Effect size *d*	Observed Power
Inversion Torque (lb-ft)	15.9 (10.6, 7–48)	13.8 (9.4, 3–39)	0.40	0.2	0.05
Eversion Torque (lb-ft)	12.5 (7.2, 2–27)	14.9 (7.2, 6–29)	0.33	0.3	0.05
Best Reaction Time (sec)	0.38 (0.07, 0.26–0.47)	0.39 (0.07, 0.31–0.54)	0.71	0.1	0.05

Table 2. Correlation coefficient between variables of interest. Bold value means statistical significance.

Reaction Time		**Left**		**Right**	
		Inversion Torque	**Eversion Torque**	**Inversion Torque**	**Eversion Torque**
Right	*r*	-0.28	**-0.53**	-0.21	-0.10
	p	0.28	**0.03**	0.41	0.70
Left	*r*	-0.26	-0.45	-0.24	0.02
	p	0.31	0.07	0.35	0.94

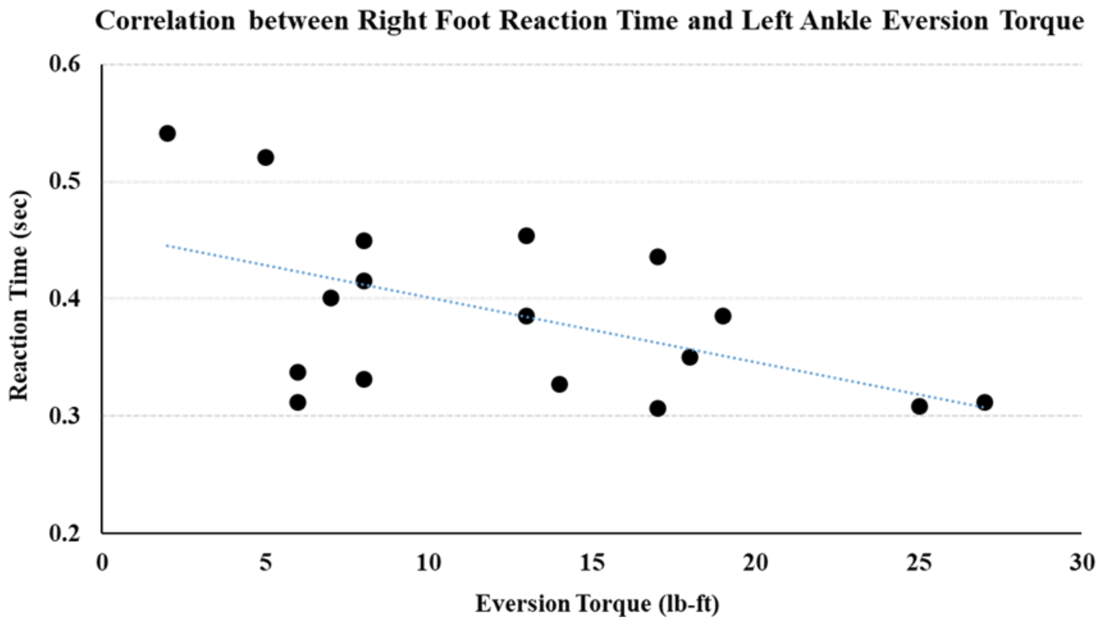

Figure 1. Relationship between best reaction time of the right foot and left ankle peak eversion torque.

DISCUSSION

Given that reaction time is largely dependent on strength (11), the purpose of this pilot work was to explore the relationship between foot reaction time and ankle strength in female collegiate soccer athletes. We focused on determining the relationship between lower body extremity reaction time and ankle frontal plane torque since no previous studies have investigated such an important motion, specifically with women soccer athletes (10).

A plausible rationale for our regression findings can be seen with the investigation of plantar pressure profiles during the soccer-specific tasks of running, cutting maneuvers, and landing (22). While higher pressure gradients were observed under the dominant foot when the generation of force was the goal, the non-dominant foot's pressure profile was higher when accomplishing tasks involved body stabilization. Since our participants were all right lower limb-dominant, this report provides support for the significant result of the non-dominant (i.e., left) ankle torque explaining the large variance in the dominant (i.e., right) foot reaction time given the goal of the task was to accomplish the movement as fast as possible while maintaining balance.

In agreement with our hypothesis, left ankle eversion peak torque not only was correlated with right foot reaction time, but it also explained why over half of the variance was observed in the right foot versus the left foot. It was also interesting to note when the soccer athletes stepped on the switch mat to stop the timer, most athletes stepped back to the initial athletic starting position, which was not required. This voluntary action seemed reasonable due to the ankle evertors from the support limb would contribute to the completion of this experimental task. Additionally, literature (2) suggests that the evertors peroneus longus and brevis also contribute as agonists of plantarflexion. This additional agonistic action serves a role in stabilizing and positioning the support limb for the dominant moving limb to complete the stepping task more quickly. When considering the skill of slalom dribbling, while the non-dominant foot is on the turf, the opposite and dominant limb will carry the ball through the side to side opposing movement which supports our result of the investigation. Although the interaction with the ball is outside the scope of our study, the knowledge that greater strength of the non-dominant ankle evertor can impact right lower limb reaction time could be directly translated to this motor skill and guide soccer task-specific training successfully. Even though past literature compared dominant to non-dominant limbs (13, 15), the authors specifically focused on classifying right and left side comparisons even though all the female participants in the study were right foot dominant. The various usage of measuring isokinetic strength or torque with soccer athletes have been frequently described in the scientific literature (6, 16, 20) but not with ankle inversion or eversion peak torque. Ergün et al. (6) measured peak torque using an isokinetic dynamometer as an essential tool analysis only on the knee and hip joints. Our study demonstrated eversion peak torque of the right ankle was essential to promote reaction time which could possibly assist with knee and hip peak torque. In soccer, it is normally understood that the quadriceps muscle plays an important role in the execution of sprints, jumps, kicks, and passes, while the hamstrings mainly act as stabilizers of the knee joint during changes of speed and direction through the actions of slalom dribbling. These upper extremity prime movers could possibly contribute towards nervous responses towards the lower extremities such as the ankle and foot during dynamic movements during soccer play.

Although significant results were obtained, this is still a pilot work that was conducted to explore ankle frontal plane strength and lower limb reaction time. A larger sample size could address the non-significant results observed in our study as well as allow for the inclusion of other independent variables in the regression model. In addition, movement time was not considered in this study. Lastly, peak torque in the sagittal plane was not investigated in the same cohort of athletes. Future work should allude to these recommendation as well as to investigate gender differences, reaction to movement time, different turf sport athletes, and coincidence anticipation time to elucidate our findings.

The findings of our pilot work suggest that ankle frontal plane peak torque is related with opposing foot reaction time. Specifically, soccer athletes who exhibited greater evertor peak torque performed the foot reaction time task significantly faster. Thus, strengthening the non-dominant ankle evertors can likely contribute to the opposite, dominant foot's reaction time. However, our results are limited to the left ankle evertor only and further work should be performed with larger sample sizes to elucidate our findings.

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