**GROUND REACTION FORCE DOMINANT VERSUS NON-DOMINANT SINGLE LEG STEP OFF**

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**ABSTRACT**

**Introduction:** Most individuals rely heavily on what they consider their dominant leg. Studies have found the the ground reaction force (GRF) of the dominant leg is less in comparison to the non-dominant leg because of the decreased flexion of the hip, knee and ankle. The decrease in flexion enables a decreased GRF when landing on the non-dominant leg. This coincides with our studies where we found that leg stiffness is greater in the non-dominant leg in comparison to the dominant leg. The dominant leg is able to absorb the impact better when stepping or jumping as opposed to the non-dominant leg. **Aim:** The purpose of our study was to determine when stepping off a platform, which leg would result in the greatest ground reaction force, the dominant or non-dominant leg. **Methods:** The study consisted of 10 subjects recreational active, 5 males and 5 females, age 23.6 years, ± 3.04yrs, height 1.72m, ± .08m and weight in kilograms 75.12kg, ± 13.76kg. Subjects were asked to self report their dominant leg, which was recorded for all subjects, only one subject stated they were left leg dominant. The subjects were instructed to step off a 16 inch tall aerobic step platform onto a force platform, alternating between their dominant and non-dominant legs. The height difference between the step and force platform was 12 inches. **Results:** The results concluded that the greatest amount of ground reaction force was produced primarily by the non-dominant leg. The data based upon the joint angles produced when stepping off the step platform indicates there is no major difference between dominant and non-dominant legs. The data results also indicated that subjects had an increase in leg stiffness of their non-dominant in comparison to their dominant leg. **Conclusion:** Our findings supported our hypothesis, when stepping off the aerobic step platform onto the force platform with the non-dominant leg the ground reaction force will be significantly greater.

**INTRODUCTION**

Everyday, people depend on their dominant leg for many tasks. In sports, athletes may kick with their dominant leg because it is assumed to be stronger and more coordinated than the opposite leg. When falling forward the dominant leg is more likely to be used to prevent the fall. Our research group questioned if there was a significant difference between the force productions of the dominant leg versus the non-dominant leg while landing barefoot off a 16-inch step.

Our research group has hypothesized that the non-dominant leg will produce more force than the dominant leg. When comparing Schmitz’s and Fong’s study, which analyzed the kinematics of the leg when landing from a specific height, Fong (2011) concluded that the ankle, knee and hip angles determine the ground reaction force when landing (p. 9). Similarly, Schmitz (2007) found that the dominant leg joint angles are smaller resulting in decreased GRF values in comparison to the non-dominant leg (p. 687).

Researchers have conducted similar studies to determine whether or not single-leg landings produce a greater force by testing lower extremity biomechanics and muscle activation. According to Wang (2011), single-leg landings produce a greater vertical ground reaction force as a result of the “knee kinematics during the landing phase” (p. 154). Knee kinematics was determined by measuring the hip and knee flexion angles as the foot made contact with the ground (Wang, 2011, p. 154). In another study conducted by Brown et al. (2010) lower limb muscle activation and knee kinetics during single-leg landings were observed. The results concluded an “increased rectus femoris pre-activity during a unilateral landing may be critical for increased eccentric load-induced knee joint stiffness and stability to counter the rapidly decelerating body center of mass on a single leg support” (Brown et al. 2010, p. 3). Another study was conducted to focus on the effect of the knee flexion angle on the ground reaction force for single-leg landing, and it was inferred that the ground reaction force was not as great when the knee was flexed, whereas they were much greater when the knee was extended (Podraza et al, 2010, p. 294).

Although, the studies referenced were not primarily focused on finding the ground reaction force difference strictly between non-dominant and dominant leg, they were interested in finding a difference between the force produced by single-leg landings. Our study however, is primarily focused on discovering whether or not the force produced by the non-dominant leg is greater than the force produced by the dominant leg.

**METHODS**

The study consisted of 10 recreational active subjects, 5 male and 5 female, age 23.6years, ± 3.04years, height 1.72m, ± .08m and weight in both kilograms and Newtons 75.12kg, 736.63N, ± 13.76kg, 134.94N. The subject’s identified their dominant leg and only one subject identified the left leg as dominant. Each subject was instructed to complete one practice trial for each leg for familiarization. Each practice trial consisted of one double leg landing and two single leg landing for both the dominant and non-dominant leg. The first test trial consisted of the subject stepping up on the steps next to the force platform. Each subject was instructed to perform two consecutive single step-offs on their dominant and non-dominant leg.

The force platform was placed between two 16-inch steps. Each participant was required to step onto one of the 16-inch steps. They were directed to step down from the step with the leg facing the camera onto the force platform. This was repeated on the opposite step. Each participant completed two trials consisting of two step offs for each leg. Therefore, two step-downs were completed by each leg within a 30 second time frame. The steps used were aerobic steps (The Step, Marietta, Georgia 30067 USA) The Step height measured 16 inches from the ground. The height distance between the step-off platform and the force platform was a 12” inch difference.  A Biomechanics Force Platform was used to record the force upon impact of the subject stepping off the step onto the force platform (FP4060-15-2000, Bertec Corporation 6171 Huntley Road Suite J Columbus, OH 43229 U.S.A.).

The subjects were recorded using a canon ZR900 mini DV camera at 30Hz (60 Hz de-interlaced), while utilizing a 1-meter stick as a spatial reference for the software for motion tracking analysis MaxTRAQ 2D (innovision systems). The camera was used to record and observe the landing for both dominant and non-dominant legs.  Camera footage was digitized by the MaxTRAQ 2D software, by placing markers on the hip, knee, ankle and toe to find leg compression based upon the angles of the hip, knee and ankle joints. The joint angles were then used in conjuction with the ground reaction force peak values to calculate leg stiffness. In this study, it was assumed the ground reaction force and leg compression coincide with each other to calculate leg stiffness; the footage and force platform are not linked and therefore is an assumption.

Data was collected and computed with the force platform software custom routines formated in MATLAB (R2009, Natick, MA). Values of the peak ground reaction force were analyzed through SPSS, software version 18.0 (SPSS, IL) and Microsoft Excel (Microsoft Excel 2011,). A paired t-test was used to compare the means between single right leg step off and single left leg step off. A Pearson correlation was used to determine if a significant correlation is present. All values are reported as mean ± SD. Statistical significance was set at p<0.05.

**RESULTS**

Out of the original ten subjects nine yielded usable data. Of the nine subjects tested eight claimed their right leg to be dominant, and one claimed left leg dominance.  The mean left knee angle at landing was 32.6**°**, ± 5.9**°**. The left ankle angle mean was 47.7**°**,± 5.5 **°**. The mean for the right knee angle at landing was 31.4**°**, ± 5.7**°**, and the right ankle mean was 49.8**°**, ± 5.5**°**. There was no significant correlation between the landing angle when comparing the dominant and non-dominant leg. Although, the ankle angle was consistently higher than the knee for every landing. The mean and standard deviation for single right leg step off ground reaction force 1573.1N, ± 541.07N (Figure 1). The mean and standard deviation for single left leg step off ground reaction force 1929.5N, ± 503.91N (Figure 1)The Pearson correlation showed significance for single right leg step off ground reaction force versus single left leg step off ground reaction force (Pearson correlation= .912). A paired t-test with a set alpha level p<0.05, showed significance for single right leg step off ground reaction force versus single left leg step off ground reaction force (p=.001). Left leg stiffness mean and standard deviation was 61.8Nm, ± 21.6Nm (Figure 2). The right leg stiffness mean was 52.7Nm, ± 24.9Nm (Figure 2). The data indicated all subjects ground reaction force increased overall for the non-dominant leg, which was the left leg for almost all subjects except one. Figure 1Figure 2

**DISCUSSION**

The purpose of our study was to determine when stepping off a platform, which leg would result in the greatest ground reaction force (GRF), the dominant or non-dominant leg. We speculated that the motor muscle control was more efficient in the dominant leg. Thus, our research group hypothesized that the non-dominant leg would result in a greater GRF when compared to the dominant leg. Our results concluded that our hypothesis was accepted and supported by our data that shows the non-dominant leg produced a greater GRF (Figure 1). Despite the data supporting the hypothesis there was one subject that did not show a greater GRF with their non-dominant leg. This could be a result of the subjects self-reporting their dominant leg.

According to a previous study done by Wang (2010), a greater ground reaction force production is due to “decreased hip and knee flexion angles at initial foot contact with the ground, decreased maximum hip and knee flexion angles during landing, and a decreased knee flexion angular velocity at initial foot contact with the ground” (p. 154). In this study there was no association between decreased joint angles and an increased GRF. This contradiction may be an effect of the small sample size as well as the granular and pixelated video footage. If decrease joint angles caused an increased GRF this would be important because, if repeated at a constant rate the joints and bones of the lower extremity can be damaged due to the greater impact at the time of landing. The absence of a control group and medical evaluation for comparison may have prevented more accurate results and the ability to expand on this topic, but could be done in later studies.

Due to the increased hip, knee, and ankle flexion displacement, dorsiflexion range of motion is greater, which enables a decreased ground reaction force during landing. This suggests “heel to toe landings resulted in less sagittal plane displacement at the ankle, knee, and hip and greater vertical ground reaction forces” (Fong et al, 2011, p. 9). It can be said that these applied aspects of biomechanics during foot landing decrease the ground reaction force impact upon the lower extremities. The decreased impact on the lower extremities decrease the risk of injury because, “immediately after ground contact, the knee is forced into flexion by vertical and posterior ground reaction forces and downward acceleration of the body’s center of mass” (Fong et al, 2011, p. 9).

According to Van de Harst et al (2007), statistics show that there was no significant difference when comparing the dominant and non-dominant leg; the dominant leg was determined as the leg that reached the biggest horizontal distance. In this study a correlation between leg stiffness and GRF was found. The greater the leg stiffness the greater the GRF. Eight out of the nine subjects that we collected data from showed that their non-dominant leg was stiffer than their dominant leg, thus created a greater GRF.

Many studies have looked at the effects that vertical jumps and long jumps have on GRF.  Others have compared single and double- leg jumps as well as male and female biomechanical and physiological aspect of GRF. Although, not much research has been documented on the effects of dominant versus non-dominant leg GRF. This study can be used as a precursor for furthering such research in future studies. This study could also be developed further to help prevent certain injuries, such as rupturing the ACL or overloading the knee.

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