COMPARISON IN FORCE GENERATION AND TIME OF FOOT CONTACT IN FOUR DIFFERENT CUTTING ANGLES BETWEEN ATHLETES AND NON-ATHLETES

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The purpose of this study was to determine the differences in peak active vertical ground reaction force (vGRF) and time of foot contact in four different cutting angles of a closed-loop situation between two groups. A total of 10 participants (n=5, athletes, n=5, non-athletes) ran across a force plate to measure peak active vGRF and time of foot contact in four different angles. Data were analyzed using two 2x4 mixed-design ANOVA ($p<0.05$). Results showed athletes produced higher active vGRF in the shorter time of foot contact, compared to the non-athletes. The result showed a significant interaction with the angles and the participants in the time of foot contact ($F(3,24) = 4.48$, $p<.05$). The athletes had overall movement efficiency in the closed-loop condition as compared to the non-athletes.

KEY WORDS: movement efficiency, closed-loop control, cutting angles.

INTRODUCTION: It has often been wondered how athletes can make quick decisions during the events of an athletic contest, while maintaining the appearance of fluidity. The decisions made are translated into quick adaptations of movement based on the changing environment. Information received by the brain based on the environment is rapidly assessed by the motor system and changes are made in movement based on the new information. The ability of athletes to make quick adaptations or adjustments in their movement is based on their closed-loop motor control system. The closed-loop motor control system is used to integrate constant changes in the environment to the adjustments made in movement used to adapt to those changes. The motor control system is the central processing unit that takes in new input from the environment and sends feedback to the brain, which in turn sends the new information to the nervous system to make the proper changes in movement (Schmidt, & Wrisberg, 2004). This processing unit is essential when the environment in which we perform in is changing constantly. In the realm of sport and athletic performance, the closed-loop system is important for the ever-changing environment. In order for athletes to be successful, they must be able to make adjustments in their movement. During the course of a contest, the unpredictability of the opponent forces the athlete to rapidly make changes to their movement, as well as momentum.

Recent literature has examined the closed-loop control system in athletes' function when performing tasks. The closed loop system in soccer players was examined during penalty kicks in order to determine an optimum time for penalty kickers to change the direction of their desired kick based on the movement of the goalkeeper (Morya, Ranvaud, & Piheiro, 2003). It was concluded that the "point of no return" for changing direction of the kick was 240-245ms before striking the ball. However, for the penalty kicker to show 100% reliability in performance, 450-500ms before the kick was needed. This study suggests that the more time an athlete has to make a decision, the better chance the feedback loop has to make adjustments in movement. In addition, several studies have compared reaction time and simple reaction time of athletes and non-athletes (Botwinick & Thompson, 1968; Kida, Oda, & Matsumura, 2005; Psalman, 2001; Smith, 1973). The bulk of these studies indicated that response time was faster and more effective in athletes than in non-athletes. Moreover, one research study also attempted to show how the closed-loop system is much more effective in athletes than that of untrained or unfit individuals (Etnier, Sibley, Pomeroy, & Kao, 2003). The effects of aerobic fitness and age were examined in an attempt to show how age and fitness levels impacted response time in closed-loop tasks. This study showed that age and age by fitness negatively affected response time for selected closed-loop tasks.

Although faster reaction time for athletes is evident, a selected kinetic measure has not been studied. Therefore, the purpose of this study was to determine the differences in peak active vertical ground reaction force (vGRF) (push-off phase of the vGRF) and time of foot contact in four different cutting angles between two groups of participants (athletes & non-athletes). The hypothesis of this study was the peak active VGRF was assumed to be a similar amount between athletes and non-athletes, but time of foot contact is faster for athletes in all four angles as compared to the non-athletes.

METHOD:

Participants: A total of 10 participants volunteered for this study. Five collegiate soccer players (age, 18.6+0.5yr.; height, 170.4+3.2cm; weight, 68.4+3.1kg) and five healthy young adults (age, 20.2+1.3yr.; height, 176.0+5.3cm; weight, 74.2+5.3kg) volunteered for this study.

Procedures: All participants reported to Barry University Biomechanics Laboratory at the date of the data collection. After an adequate amount of stretching, the participants started at a distance of 4 meter from the force plate, and then ran to step on the force plate with an opposite foot of the direction they were guided to go by the instructor. The peak active vGRF was measured by an AMTI force plate (Advanced Mechanical Technologies, Inc., Watertown, MA) that sampled at 600 Hz. The Peak Motus software (ver. 8.2, ViconPeak, Centennial, CO) was used to reduce the data with Fast Fourier Analysis. The peak active vGRF was normalized mathematically to body weight (BW), and averaged for the groups. To maximize the concepts of closed-loop control in cutting movement, the investigator provided a direction sign (e.g., L30, L60, R30, & R60) prior to the start, and then switched the sign to the different directions at 3 meter prior to reaching the force plate. Visual demonstration and verbal instruction were provided to place a foot on the force plate properly. Participants were instructed to run with a comfortable pace (2-2.5m/s), and were also allowed to practice until they feel comfortable with a proper foot placement and running speed. Four trials (one trial per angle) were given to each participant, as the signs were assigned randomly.

DATA ANALYSIS: Microsoft Excel (Microsoft, Inc, Redmond, WA) was used to generate graphs to simplify the comparison of the average peak active vGRF and the average time of foot contact between the athletes and the non-athletes. The results of this study were analyzed using two separate 2*4 (athletes/non-athletes*4 cutting angles) mixed-design ANOVA performed in the Statistical Package for Social Sciences (SPSS) (SPSS, Inc., Chicago, IL). The test was performed for each dependent variable: the peak active vGRF and the time of foot contact.

RESULTS: The results showed that the athletes had a higher overall peak active vGRF when changing the directions with shorter time of foot contact as compared to the group of non-athletes (see Figures 1 & 2). The average peak active vGRF of 60-degree directions (L & R) from the athletes was 2.14+0.32* body weight (BW), as compared to the non-athletes with 1.81+0.11*BW. The average time of foot contact of 60-degree directions (L & R) from the athletes was 0.21+0.06 sec., whereas the group of non-athletes was 0.30+0.05 sec. The average peak active vGRF of 30-degree directions (L & R) from the athletes was 2.11+0.21*BW, as compared to the non-athletes with 1.85+0.15*BW. The average time of foot contact of 30-degree directions (L & R) from the athletes was 0.27+0.06 sec. whereas the group of non-athletes was 0.29+0.04 sec.

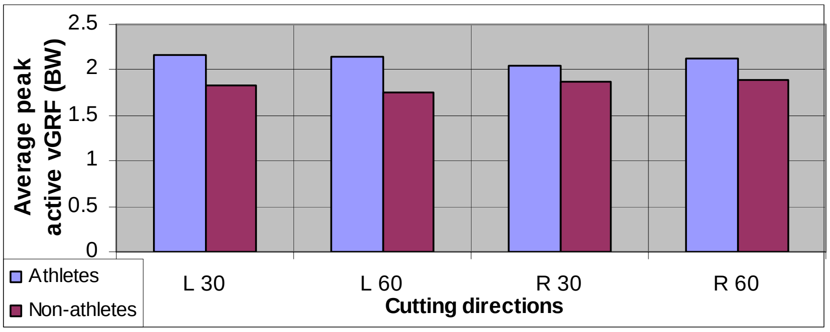

Figure 1: Comparison of average active vertical GRF of four angles between athletes and non-athletes

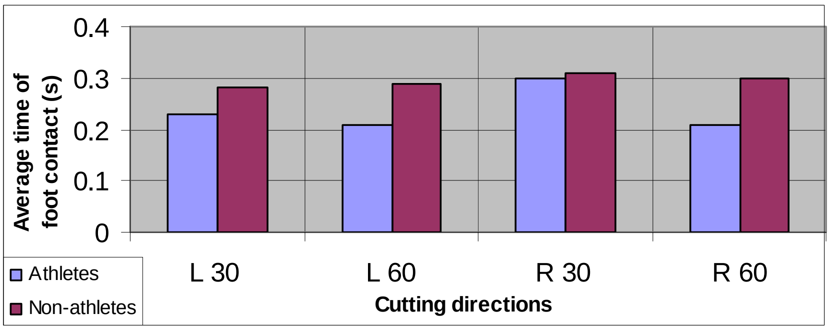

Figure 2: Comparison of average time of foot contact of four angles between athletes and non-athletes

DISCUSSION: A 2*4 mixed-design ANOVA was calculated to examine the effects of the participants (athletes & non-athletes) and angles (L30, L60, R30, & R60) on the peak active vGRF. No significant main effects or interactions were found. The angles and participants interaction ($F(3,24) = .789$, $p>.05$), the main effect for angles ($F(3,24) = .324$, $p>.05$), and main effect for participants ($F(1,8) = 6.47$, $p<.05$) were all not significant. The peak active vGRF was not influenced by neither participants nor angles. A 2*4 mixed-design ANOVA was calculated to examine the effects of the participants (athletes & non-athletes) and angles (L30, L60, R30, & R60) on the time of foot contact. A significant angles and participants was present ($F(3,24) = 4.48$, $p<.05$). In addition, the main effect for angles was not significant ($F(3,24) = 2.44$, $p>.05$). The main effect for participants was significant ($F(1,8) = 4.97$, $p<.05$).

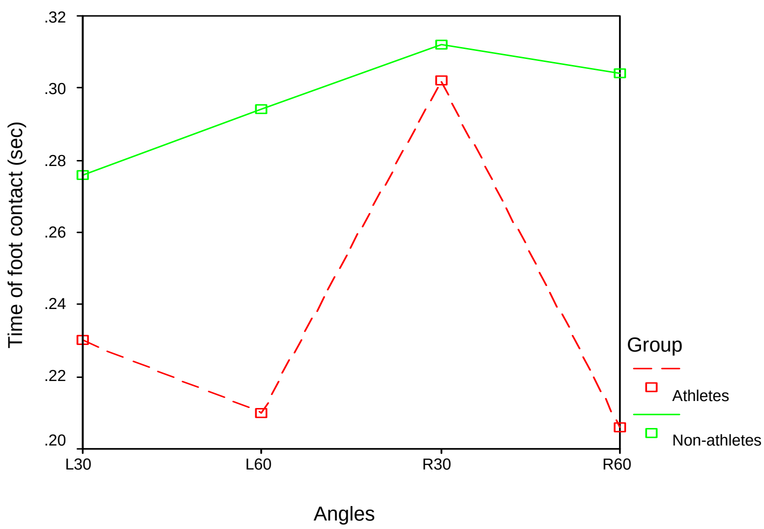

Figure 3: Comparison of average time of foot contact in four angles between athletes and non-athletes

DISCUSSION: When observing the results, the first hypothesis was not supported due to the fact that the peak active vGRF was higher by the group of athletes than the group of non-athletes. However, second hypothesis was supported that the time of foot contact was shorter by the group of athletes than the group of non-athletes. When the athletes were guided to R30 degrees, the time of foot contact was longer than they moved in all other directions (see Figure 3). As they were required to use their opposite foot of the direction they were to move, when the athletes used their non-dominant foot to move to the right, their time of foot contact was longer especially at the 30-degree acute angle as compared to all other angles and directions (Note: all participants were right-foot dominant). The findings reported by Etnier et at. (2003) indicated that trained individuals might have faster response time and better movement efficiency than untrained individuals. The present study supported the findings and indicated that because of the traits a trained person may have, as well as the experience, their closed-loop control system functions more effectively than that of non-athletes. Other studies have been done to find the "point of no return" in which individuals cannot send feedback of a desired movement fast enough the make a change in their movement pattern. Morya et al. (2003) stated that the point of no return was 240-245 ms before the movement was needed in order to effectively change directions of a penalty kick in soccer. The present study indicated that all participants succeeded the cutting maneuver without failing to step on the force plate. This indicates that 3-M provided enough time to process feedback and effectively ran to the guided direction. Overall, the athletes showed improved movement efficiency by performing the cutting maneuver with higher active vGRF in shorter time of foot contact as compared to the non-athletes.

CONCLUSION: The closed-loop control process is evident and also necessary in many athletic environments. When the body can actively respond to feedback from the brain, faster and more fluid movements can be produced. While the closed-loop system is used in unpredictable environments, evidence has been shown that practice and experience in closed-loop situations helps athletes to process the changing environment faster than non-athletes. Coaches and practitioners are recommended to engage in reactive training to improve athletes' motor-control in the closed-loop situations.

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