MUSCULAR ACTIVITY IN COLLEGIATE FOOTBALL LINEMEN WITH AND WITHOUT A PREFABRICATED FUNCTIONAL KNEE BRACE

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Functional knee braces are commonly used in the athletic realm in an attempt to prevent initial and reoccurring injuries. The purpose of this study is to evaluate muscular activity in collegiate football linemen during sport specific skills (3 point stance, lateral cutting maneuver, and drop jump). Ground Reaction force (GRF) and muscular activity of the quadriceps and hamstrings were analyzed to determine the impact of wearing a knee brace. Results showed no differences in the GRF or muscular activity of the quadriceps during any of the skills. The hamstring showed increased activity during the drop jump only. In conclusion, functional knee braces do not appear to negatively impact muscular activity during football specific drills.

KEY WORDS: Functional knee brace, muscular activity, football

INTRODUCTION: Knee injuries are one of the most prevalent types of injury in sports. It is estimated that between 13% and 71% of all athletic injuries occur at the knee joint (Rishiraj et al 2009). In an attempt to reduce knee injuries, the use of a knee brace has been widely adopted in the athletic realm. In the collegiate football domain, there is an enormous push for all linemen (especially offensive linemen) to wear knee braces regardless of past medical history. Current literature has provided mixed results and is therefore unable to provide consistent evidence pertaining to the effectiveness of knee braces (Rishiraj et al, 2009). Rishiraj et al (2009) reviewed the impact of knee braces on injury rates and reported 24 studies that found a decrease in knee injury rates while another 12 studies found no effect of the intervention. Similarly, the results on negative impacts of wearing knee braces are inconsistent (Bridge et al 2008, Rishiraj et al 2009, Smith et al 2009). Smith et al (2009) discuss a potential increase of muscular fatigue due to restricted range of motion and also suggest the bulkiness of the brace could impose altered mechanics thereby increasing the risk of injury (Bridge et al 2008). Subsequently, the possibility of harmful effects caused by knee braces in a healthy population should be investigated. The purpose of this study is to examine muscular activity during sport specific skills in collegiate football linemen with and without a knee brace. The focus will be on bilateral hinged prefabricated functional knee braces (FKB). FKBs are designed to assist with knee stabilization and help maintain normal tibiofemoral kinematics of the knee (Bridge et al 2008). Primarily, FKBs are structured to limit abnormal knee rotational and translational forces that athletes can potentially undergo during competition (Bridge et al 2008). Specifically, the aim of this study is to investigate the effect of a FKB on the muscular activity of knee stabilizing muscles and the GRFs during football specific skills in collegiate athletes. It is hypothesized that wearing a knee brace will affect the muscular activity of the quadriceps and hamstrings as well as the maximum vertical GRF experienced.

METHODS: Eight collegiate football linemen volunteered to participate in this study (age: 20 $\pm$ 2.1, height (cm): 195.5 $\pm$ 5), weight (kg): 118.2 $\pm$ 11.9). Each subject was measured (15.2cm above mid-patella, according to DonJoy's sizing recommendations) and sized for a prefabricated DonJoy Armor FourcePoint functional knee brace. Knee braces were applied to both legs but only the dominant leg was tested. The kicking leg was defined as dominant leg. This study was approved by Central Washington University's Human Subject Review Committee.

The following three skills were selected for the purpose of this study: 3 point stance, lateral cutting maneuver, and a drop jump. The participants performed each skill three times twice;

once in a no brace and once in a brace condition. The order of skills and brace or no brace condition were randomized and the explanations of the skills were:

3 point stance
One hand down on the ground as though lining up for a play and at the sound of a buzzer run forward with their dominant leg landing on the force plate
Lateral Cutting
3 meter linear run up and a 45° lateral cutting maneuver on a force plate with the dominant leg landing on the force plate
Depth jump
The subject will step off an 18in high box jump onto a force plate and as soon as the subject lands they need to jump as high as possible

Electrode placement was determined using SENIAM's recommendations (slightly modified to allow for placement of FKB) (Merletti et al 2012). The subject's skin was prepared for electrode adherence via shaving and alcohol swipe prior to electrode placement. Each subject was outfitted with a DelSys Tringo Wireless EMG electrode on their vastus medialis (VM), rectus femoris (RF), vastus lateralis (VL) (quadriceps group), biceps femoris (BF), and semitendinosus (ST) (hamstring group). Once the subject was outfitted with the EMG electrodes, they were provided a tubular compression bandage in order to ensure the electrodes remained in place throughout testing. Maximum GRF was measured using a standard force plate (AMTI 40X60cm).
Muscular activity for data analysis was attained by the root mean square (RMS). Using the no brace condition as baseline, the data was normalized defining the no brace condition as 100% reference value. The brace condition RMS and GRF values are reported as a percentage change to the no brace condition. A one sample t-test was used to compare GRF, EMG RMS values for the quadriceps (VM, RF, VL), and the hamstrings (BF, ST). The alpha level was set at $\alpha<.01$ based on Bonferroni adjustment for multiple t-tests.

RESULTS: No significant difference was found in the total vertical GRF or quadriceps musculature RMS between the brace or no brace condition for any of the skills (Figure 1).

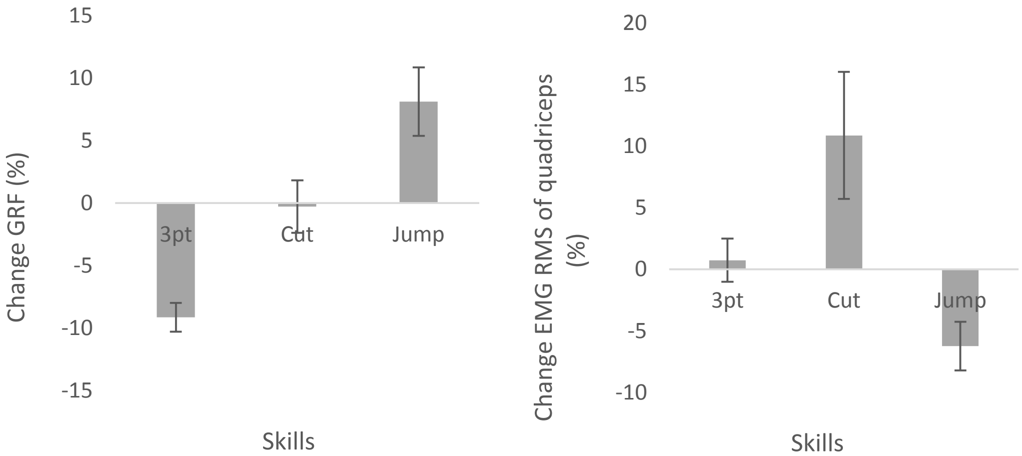

Figure 1. Changes in GRF values (mean ± SD) (left) and changes in EMG RMS (mean ± SD) in the quadriceps muscle group (right)

A statistically significant difference was found in the hamstring group during the drop jump (p=.006), but no significant difference was found in the lateral cut, or 3 point stance (Figure 3).

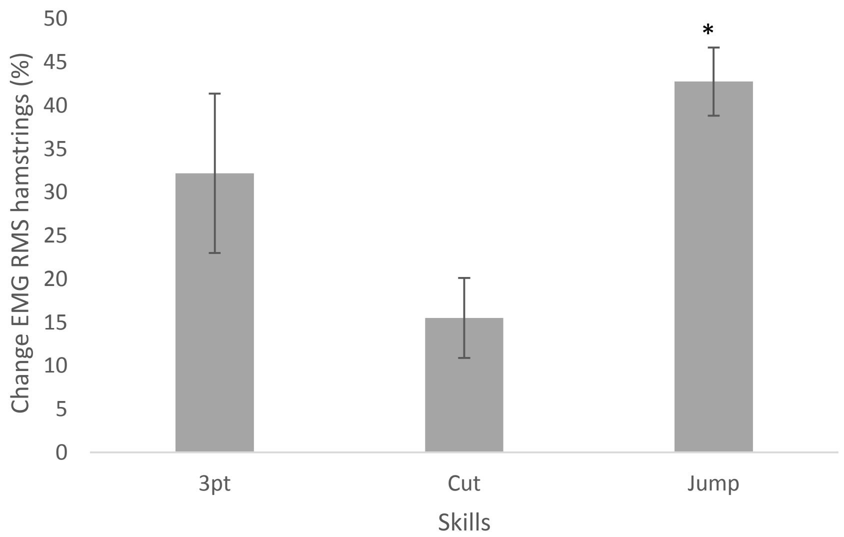

Figure 3. Changes in EMG RMS (mean ± SD) in the hamstring muscle group. The asterisk denotes significant difference in the EMG RMS (p=.006)

DISCUSSION: The aim of this study was to investigate if wearing a FKB affects muscular activity of the quadriceps and hamstring muscle group and the peak GRF. Results indicate that using FKB does not have a major impact on movement biomechanics during any of the tested skills. The muscular activity of the quadriceps did not change and the GRF was also not significantly affected. The GRF for the 3 point stance was reduced (p=.026) but the alpha level for this study was set at a stringent p<.01 in order to avoid a beta error. On the other hand the power for this component was 1 and an increased sample size might reveal significant differences.

There was a significant increase in the RMS of the hamstring group during the drop jump. Increased muscular activity of the hamstrings is associated with reduced tibiofemoral shear forces as well as reduced tension on the anterior cruciate ligament (Biscarini et al 2013). Therefore wearing a FKB might reduce the ACL tension during jumping activities in collegiate football players. On the other hand, increased muscular activity of the quadriceps in combination with reduced muscular activity of the hamstrings has been discussed as enhancing knee stability in ACL deficient subjects during one legged jumps while wearing knee braces (Ramsey et al 2003). Ramsey et al (2003) attributed the changes in muscular activation to changes in proprioceptive feedback. Further studies are needed to investigate in depth if subjects with healthy knees react differently to the brace related change in proprioceptive feedback during high impact activities.

Furthermore, muscle activity depends on movement kinematics such as knee and hip flexion. One complaint received from subjects in this study and from other studies was a noticeable lack of range of motion (Rishiraj et al 2009, Bridge et al 2008). While this study did not examine hip and knee angles, this could explain the heightened hamstring activity while the subjects were wearing a brace. In a follow up study, motion analysis data would be helpful to examine joint angles and determine their effect on muscular activation. In addition to joint angles it would also be pertinent to examine muscle activation onset duration during specific skills. This would ascertain if specific muscle groups (i.e. quadriceps or hamstrings) remain activated longer than usual during one condition versus another.

This research serves as a pilot study for examining the effect of a single type of functional knee brace on healthy knees. The research previously conducted on this population using sport specific skills is limited. Future studies should aim for an increased sample size, include kinematic data, and possibly utilize more than one type of prefabricated FKB. This study shows that the use of FKBs should be used with caution. Implementing proper strength training and familiarization periods for each athlete using a brace could help reduce the risk of injury from increased muscular activity and decreased range of motion.

Conclusion: Based on this study, some evidence has been provided on the possible effects of FKBs in a healthy athletic population. The results of this study show that there is an increase in muscular activity in the hamstrings while wearing a FKB during drop jumps. As a result, the use of a FKB should be accompanied with proper training in an attempt to reduce muscular and biomechanical effects and maintain normative joint motion.

References

Biscarini, Andrea, Botti, Fabio, Pettorossi Vito (2013). Selective contribution of each hamstring muscle to anterior cruciate ligament protection and tibiofemoral joint stability in leg-extension exercise: a simulation study. *European Journal of Applied Physiology* 113, 2263-2273

Bridge, Michael, Stanish, William, Russell, David et al (2008). Knee Bracing in Sports Medicine: A Review. *Techniques in Knee Surgery* 7, 251-260.

Merletti, R, Rau, T, Disselhorst-Klug, C, Stegman, D, & Hagg, G (n.d.) Retrieved from http://www.seniam.org

Miller, John, Vailas, James, Croce, Ronald et al (1999). Dynamic Analysis of Custom-Fitted Functional Knee Braces: EMG and Brace Migration During Physical Activity. *Journal of Sports Rehabilitation* 8, 109-122.

Onishi, Hideaki, Yagi, Ryo, Oyama, Mineo et al (2002). EMG-angle relationship of the hamstring muscles during maximum knee flexion. *Journal of Electromyography and Kinesiology* 12, 399-406.

Pietrosimone, Brian, Grindstaff, Terry, Linens, Shelley et al (2008). A Systematic Review of Prophylactic Knee Braces in the Prevention of Knee Ligament Injuries in Collegiate Football Players. *Journal of Athletic Training* 43, 409-415.

Ramsey, Dan, Wretenberg, Per, Lamontagne, Mario et al (2003). Electromyography and biomechanic analysis of anterior cruciate ligament deficiency and functional knee bracing. *Clinical Biomechanics* 18, 28-34

Rishiraj, Neetu, Taunton, Jack, Lloyd-Smith Robert et al (2009). The Potential Role of Prophylactic/Functional Knee Bracing in Preventing Knee Ligament Injury. *Sports Medicine Journal* 39, 937-960.

Schultz, Sandra, Nguyen, Anh-dung, Leonard, Michael at al (2009). Thigh Strength and Activation as Predictors of Knee Biomechanics during a Drop Jump Task. *Journal of the American College of Sports Medicine* 857-866.

Smith, Michael, Sizer, Philip, James Roger (2009). Effects of fatigue on frontal plane knee motion, muscle activity, and ground reaction forces in men and women during landing. *Journal of Sports Science and Medicine* 8, 419-427.