LONG TERM EFFECTS OF A WEARABLE NEUROMUSCULAR DEVICE ON MODIFIABLE RISK FACTORS ASSOCIATED WITH ACL INJURIES IN FEMALE COLLEGIATE ATHLETES DURING A COUNTERMOVEMENT JUMP

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The purpose of this study was to determine if a wearable neuromuscular device (WND) was successful in reducing knee valgus angle (VA), and increasing electromyography (EMG) activity of the gluteus maximus (Gmax), gluteus medius (GMed), medial hamstrings (junction of the semimembranosis and semitendinosis), and vastus medialis oblique (VMO) in female collegiate soccer players during a countermovement jump (CMJ). 15 female soccer players, were recruited to partake in a 6 week study. Over the intervention period, the intervention group (n=8) wore a WND, during active rest. It was hypothesized that the WND group would display decreased VA and increased EMG activity of the four muscles, during a CMJ, when compared to the control group (n=7). No significant difference was found between the control and intervention groups between pre and post testing ($p<0.05$).

KEYWORDS: injury prevention, electromyography (EMG), gluteus medius (GMed, gluteus maximus (Gmax), medial hamstrings, vastus medialis oblique (VMO)

INTRODUCTION: Females are 4-8 times more likely to have an anterior cruciate ligament (ACL) injury compared to males (Dedinsky et al., 2017). Approximately 70% of all ACL injuries are non-contact, and occur during a jumping or cutting maneuvers (Wetters et al., 2016; Laible et al., 2014). Female soccer players are more likely to rupture their ACL on their support leg, compared to males who are more likely to sustain an ACL injury on their preferred kicking leg (Brophy et al., 2010). Certain modifiable risk factors have been identified to be predictors of ACL injuries, these include increased knee valgus angle (VA), decreased muscle activation of the gluteus medius (GMed), and increased muscle activation of the quadriceps compared to the hamstrings (Ford et al., 2003. Serpell et al., 2015). It has been shown that medial hamstrings and medial quadriceps co-activation decrease ACL elongation, therefore decreasing likeliness of an ACL rupture (Serpell et al., 2015). Wearing neoprene sleeves has been found as productive as a functional knee brace in athletes recovering from ACL reconstruction (Brimingham et al., 2008). Compression garments have also been found to decrease recovery time from muscle damage post exercise (Bottarol et al., 2011). Decker et al. found the use of a wearable neuromuscular device, ACL Tube, which applies topical pressure to the medial hamstrings and VMO, during a jump landing task to decrease VA. However, research is lacking to determine the use of ACL Tube as a preventative mechanism for ACL injuries. The purpose of this study was to determine if the long term use of a WND (ACL Tube) was successful in decreasing knee VA, and increasing muscle activation of the gluteus maximus (GMax), GMed, medial hamstrings, and vastus medialias oblique (VMO) during a CMJ, in female collegiate soccer players. It is hypothesized that the intervention (WND) group will show a decreased knee VA and increased muscle activation of the GMax, GMed, medial hamstrings, and VMO during a CMJ after a six week intervention period when compared to the control group.

METHODS: Prior to data collection, each participant signed an informed consent form which was approved by Point Loma Nazarene University Institutional Review Board (IRB). A power analysis was done prior to data collection to determine sample size, alpha was set at 0.05, power at 0.80, and effect size of 1.0, yielding a sample size of 10. A total of 15 participants took part in this study. One subject dropped out before post testing due to a severe lower extremity injury that occurred outside of the study, during the intervention period. Personal

information including age (19±0.72), height (166.12cm±6.28), weight (63.21kg±5.26), dominant leg, and quadriceps circumference were gathered.
For each participant, 29 passive reflective markers were placed on the skin surface according to Helen Hayes marker set (Zuk et al., 2015). During each movement, 3D motion capture was recorded using a motion analysis system of 8 visible-red cameras (Kestrel, Motion Analysis Corp., Santa Rosa, CA) integrated with the Cortex motion capture software at a sampling rate of 240 fps. An 8-channel Bagnoli electromyography (EMG) system (Delsys, Natic, MA) at a sampling rate of 1920Hz was used to measure muscle activity. Surface of the skin was cleansed with alcohol wipes before surface electromyography (EMG) electrodes were applied on the skin overlying the GMax, GMed, medial hamstrings (the junction of the semimembranosus and semitendinosus), and VMO on the non-dominant leg. Muscle activation was measured throughout the movement. All EMG data was normalized to the activity max, and the percent of change from pre testing to post testing was recorded. Participants then performed a CMJ in the capture volume, consisting of the athlete jumping from a 50cm box, onto the ground, then immediately after initial contact, participants were instructed to go into a maximal vertical jump. A total of 5 CMJ were collected during the testing period. The same protocol was followed for pre and post testing. The same researcher applied markers and surface EMG to maintain consistency. Once the initial testing was completed, WND were randomly distributed to 8 participants, which made up the experimental (WND) group, the remaining 7 participants served as the control group. Participants in the WND group were instructed to wear the WND for 1.5 hours every day during activity for 10 days; then after the 10 days, they wore the garment every other day for 1.5 hours of activity for the remainder of the 6 week training period. Participants were instructed that the WND was not to be worn during team practices or strength and conditioning sessions. The WND group was also informed to place the buttresses, which apply topical pressure to the specified muscle, vertically overlying the VMO, 1.27cm above the bottom of the garment, and the second buttress horizontally over the medial hamstrings 2.54cm from the seam of the garment. After the 6 week intervention period, all participants returned for the final testing where they performed the same tests prior to the training period.
STATISTICS: The control group and the intervention group made up the independent variables. Valgus angle, and EMG of the GMax, GMed, medial hamstrings, and VMO served as the dependent variables. SPSS (IBM, Armonk, NY) was used to run a 2x2 repeated measures ANOVA determine differences in the VA between pre and post testing, between groups and within subjects. Independent t-tests were ran to determine the changes in EMG between pre and post testing.

RESULTS: The results of VA are expressed in Table 1 for the 14 athletes whom completed both pre and post testing. Knee VA in the control group at baseline for the non-dominant leg was 7.8 ±7.8 degrees of valgus, compared to the post which was recorded at 2.6 ±7.7 degrees; yielding a decrease in VA of 5.2 degrees. The baseline in the control group's dominant leg VA was 0.2±4.3 degrees of valgus angle, compared to the post testing which showed a VA of 2.8±3.0 degrees; yielding an increase in VA of 2.6 degrees. The baseline measurement of the non-dominant leg VA for the WND group was 8.0±7.5 degrees, compared to the post which showed a VA of 7.0±8.7 degrees, yielding a decrease in VA of 1.0 degree. The dominant leg VA in the WND group at baseline was recorded at 0.8±6.3 degrees, and 3.9±6.7 degrees for post testing; yielding an increase of VA of 3.1 degrees. No statistically significant differences were found between groups ($p > 0.05$) or within subjects ($p > 0.05$) for VA. The control group showed an increase in GMax muscle activation of 0.72%, and the WND group yielded an increase of 0.38%. The control group showed an increase in GMed muscle activation of 1.16% and the WND group had a decrease of -0.01%. The control group had an increase in medial hamstrings muscle activation of 0.2% compared to the WND group who showed an increase of 0.95%. The control group showed an increase in VMO muscle activation of 0.16% and the WND group showed a decrease in VMO muscle activation of -1.4%. Table 2 reflects the results of EMG of the GMax, GMed, medial hamstrings, and VMO between groups (p>0.05) and within subjects (p>0.05), no significant difference was found.

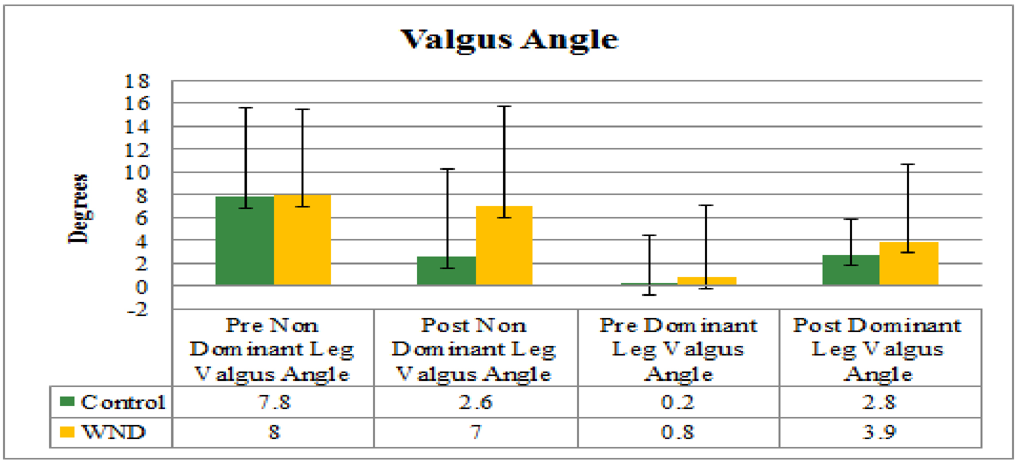

Figure 2: Knee valgus angle at initial contact during a countermovement jump

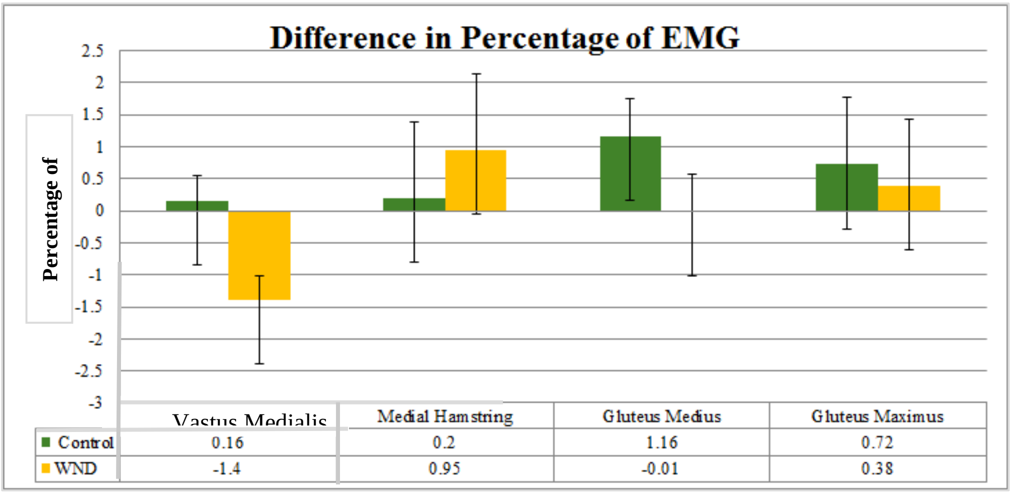

Figure 1: Percentage of change in EMG between pre and post testing.

DISCUSSION: This study showed that the use of a WND was not successful in reducing knee VA, or increasing muscle activation of the GMax, GMed, medial hamstrings, or VMO during a CMJ in collegiate soccer players. Both groups had a decrease in VA on the non-dominant leg and an increase in VA on the dominant leg between pre and post testing; however, these changes were of no statistical significance. The decrease in percentage of change in muscle activation of the GMed, in the WND group, is concerning as the main role of the GMed is external rotation of the femur. The most common mechanism of ACL injury is internal rotation of the hip on a closed chain, with an external force applied to the lateral knee; an active GMed, preventing and/or controlling internal rotation of the hip is crucial in reducing risk of ACL injury. An underactive GMed is commonly associated with an increase in VA during high risk movements (Jackson et al., 2017). The increase in VA in the WND group between pre and post intervention could be a consequence of underactive GMed.

Some limitations include; only highly trained athletes were tested perhaps adolescent athletes, who are still developing, would have benefited greater from this intervention program. This method could be found more beneficial as a rehabilitation technique as neoprene sleeves and kinesiotape have been deemed successful in promoting recovery and increasing EMG of hamstrings and quadriceps of post ACL-R patients (Fu et al., 2008; Brimingham et. al, 2008; Murray et al., 2000). Another limitation was, EMG was not measured against the participant's maximal voluntary contraction (MVC) for the specified muscle. This comparison to MVC's could elicit a more exact measure of muscle activity. Compliance was another limitation of this study, as participants expressed protocol was followed approximately 80%. Participants expressed the difficulty to find time of active rest during school, work, and soccer schedules. Bulkiness of the garment itself was reported to be difficult to wear with everyday clothing. Participants explained that once the protocol changed from every day to every other day, it was easy to forget to wear. Lastly, this study took place during the off season; with pre testing conducted during the start of the off season, and post testing towards the ladder. It could be concluded that as conditioning tapered down, so did muscular strength and endurance. Although this was accounted for, in regards that all subjects were from the same team, it is unclear if some athletes participated in outside strength and conditioning programs when others did not; which could have greatly influenced the data.

CONCLUSION: The use of a wearable neuromuscular device, as an intervention, does not decrease VA or increase muscle activation of the GMed, GMax, medial hamstrings, or VMO during a CMJ. A WND could increase VA during a CMJ as well as decrease muscle activation of the GMED. Such decrease in muscle activation being a direct risk factors of ACL injuries. Concluding that the use of a WND is unsuccessful in reducing modifiable risk factors that are commonly associated with ACL injuries.

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