OMEGA-3 SUPPLEMENTATION ON MUSCLE ACTIVATION PATTERNS OF THE KNEE DURING HIGH-RISK MOVEMENTS FOR ACL RUPTURES

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The purpose of this study was to evaluate the role of omega-3 supplementation on fatigue and neuromuscular activation patterns of the lower extremity during a drop vertical jump (DVJ) and cutting maneuver. Seventeen female soccer players were allocated to a placebo (n=7) or omega-3 (n=10) (2.4g/day) group and were assessed before and after an 8-week period. EMG of the vastus lateralis (VL) and biceps femoris (BF) was evaluated during a DVJ and cutting maneuver prior to, and immediately following, a sport specific fatigue protocol. A 2x4 RM ANOVA revealed statistically significant ($p \leq 0.05$) increases in VL activation 100ms before initial contact (IC) during each movement assessed, and 50ms before IC during the DVJ on both limbs in the placebo group following the intervention. A significant increase in VL activation in the non-fatigued state 50ms before IC was reported in the omega-3 group during the DVJ on the dominant limb, following the intervention. Subtle changes in group means, in the fatigued cutting maneuver on the non-dominant limb, indicate a potentially beneficial adaptation in percent activation (Pre: 31±5% Post: 42±12%) and rate of activation (Pre: 106±60ms, post 30±10ms) for BF activity during weight acceptance in the omega-3 group. In conclusion, omega-3 supplementation increased activation of the VL 50ms before IC during the DVJ on the non-dominant limb in the fatigued state, post-intervention; but had no further statistically significant impact on muscle activity or rate of activation, following the 8-week period.

KEYWORDS: Electromyography (EMG), anterior cruciate ligament (ACL), injury prevention, omega-3, cutting maneuver, drop vertical jump

INTRODUCTION: Predictors of anterior cruciate ligament (ACL) injuries include, increased knee abduction angels and moments, increased ground reaction forces, and decreased hamstring to quadriceps ratio (H:Q)(Hewett et al., 2005). A delay in activation of the hamstrings relative to the quadriceps increases the tensile force applied to the ACL during landing tasks (Dedinsky et al., 2017). The accumulation of fatigue results in a decline in neuromuscular control (Cortes et al., 2012), which can increase the risk of injury, particularly in those who have pre-existing neuromuscular imbalances (Dedinsky et al., 2017). Fatigue is factor which has been debated to be a risk factor for ACL ruptures. Investigations have observed an increase in ACL injuries occurring towards the latter portion of training sessions and matches when athletes are near peak exhaustion, highlighting the determents of fatigue on risk of injury (Hawkins et al. 2001). Many athletes take to dietary supplements (e.g. creatine, nitrate, β-alanine) to combat these factors. However, the long-term effects of supplementing certain ingredients can lead to deleterious effects. Highlighting the demand for dietary supplements which enhance athletic performance, are acceptable to consume, and do not negatively affect health. Omega-3 polyunsaturated fatty acid is lacking in most Western diets, but holds the potential to increase aerobic metabolism, decrease delayed onset muscle soreness, and increase collagen production within ligaments (Da Boit et al., 2017; Hankenson et al., 2000). This shift in cardiovascular function has the potential to enable athletes to increase functionality at any given work rate. A delay in the onset of fatigue will allow athletes to perform high-risk tasks with proper neuromuscular activation patterns towards the end of match-play, which will reduce the forces acting on the kinetic chain. The aim of the study was to evaluate the effects of an omega-3 supplement on muscle activation patterns of the BF and VL in female soccer players after a sport specific fatigue protocol. It was hypothesized that post-intervention and post-fatigue; participants in the omega-3 group would elicit increased muscle activation, and rate of activation, of the BF and VL during a cutting maneuver and drop vertical jump (DVJ), when compared to the placebo.

METHODS: Before testing, institutional ethics was obtained from Abertay University and written informed consent and a PAR-Q was acquired from 22 participants (omega: n=11 24±5years, 165±8cm, 62±5kg; placebo: n=11 21±3years, 166±7cm, 65±8kg). Inclusion criteria included female soccer players between 16-35 years, minimum of 1-year participation on an organized team, no history of ACL-reconstruction for 2-years prior, free from serious lower extremity injury 3-months prior to testing. Two participants in the placebo group were unable to return for post-testing due to the COVID-19 pandemic, three others (1 omega group, 2 placebo group) did not return for post-testing for reasons not disclosed; 17 participants completed pre and post-intervention measurements (omega n = 10; placebo n = 7).
Surface electromyography (EMG) electrodes were placed overlying the muscle belly in the direction of the muscle fibres of the VL and BF. 3D motion analysis (VICON Nexus 2.9) was used to determine initial contact and peak knee flexion angle during each movement assessed. EMG data was recorded at 1000Hz with Megawin software (Mega Electronics, Kuopia, Finland) and filtered using a band-pass filter 12-450Hz with 60dB attenuation and 20Hz of transient bandwidth cut off frequency. At the start of each testing session, participants completed a single leg drop vertical jump (SL-DVJ) from a 31cm box to determine maximal dynamic activation (MxDA) of each muscle. EMG values from these SLDVJ were used to normalize subsequent EMG data collected during test trials. Test trials included, 2 DVJ from a 27cm box and a cutting maneuver where they were instructed to hop over a 26cm hurdle, land on their dominant foot, then immediately cut 90° to their non-dominant side. Cutting maneuvers were performed twice on each limb. After pre-tests, participants completed the fatigue protocol (10 jump squats, 20 walking lunges, L-drill, Agility ladder) (Lucci et al., 2011). The fatigue protocol continued until the time it took the participant to complete one round, exceeded 50% of their baseline time. Upon completion of the fatigue protocol, post-fatigue measures were taken as per pre-fatigue testing. A root mean squared filter was applied to all EMG data, using Microsoft Excel, with a non-overlapping moving window of 20ms. EMG data from each test trial was normalized for each muscle, using the MxDA from the SL-DVJ performed at the start of each testing session. Percent of activation ($\frac{MxDA\ of\ test\ trial}{MxDA\ of\ SL-DVJ} \times 100$), along with the rate of activation were recorded for each muscle during each test trial.
Following pre-intervention testing, participants were allocated to an omega-3 or placebo group based on daily intake of omega-3, daily activity levels, VO_{2peak}, use of oral contraceptives. Participants in the omega-3 group consumed 2.4g of omega-3 (2.25g of EPA, 0.15g DHA and 0.6g of filler oil) daily over the 8-week intervention; participants in the placebo group consumed capsules with 100% filler oil and orange flavoring. Jamovi 1.2.16 was used to run a 2x4 (group x time) RM ANOVA to determine statistically significant changes (P≤0.05) between time points and groups for each dependent variable. Dependent variables were BF and VL activation 100ms and 50ms before initial contact (IC), rate of activation, and percent activation during the weight acceptance phase (IC to peak knee flexion angle).

RESULTS: A significant difference was reported between pre and post-intervention fatigued conditions, in the omega-3 group for VL activation during the DVJ on the dominant limb, 50ms before IC. Significant differences were reported between pre and post-intervention fatigued conditions, in the placebo group, for the VL activation 100ms before IC during the DVJ and cutting maneuver on both limbs, and 50ms before IC during the DVJ on both limbs, as well as the dominant limb cutting maneuver. A significant difference was reported in VL activation between pre and post-intervention in the pre-fatigued condition, 100ms and 50ms before IC on both limbs, during the DVJ, as well as for 100ms before IC during the non-dominant limb cutting maneuver, in the placebo group. No significant differences were observed in either muscle, between groups or across the intervention for peak muscle activity during weight acceptance nor for time to peak activation, during any movement. No significant differences were reported, between groups or across the intervention, for BF rate of activation nor percent activation at any time point in each movement assessed. Subtle group changes were reported in the omega-3 group, between pre-intervention (34±5%) and post-intervention (41±12%) fatigued conditions, for percent activation of the BF during weight acceptance on the non-dominant limb during the cutting maneuver. Similar findings were reported for rate of activation of the BF in the omega-3 group, between pre-intervention (110±60ms) and post-intervention (30±10ms) fatigued conditions, during the cutting maneuver on the non-dominant limb.

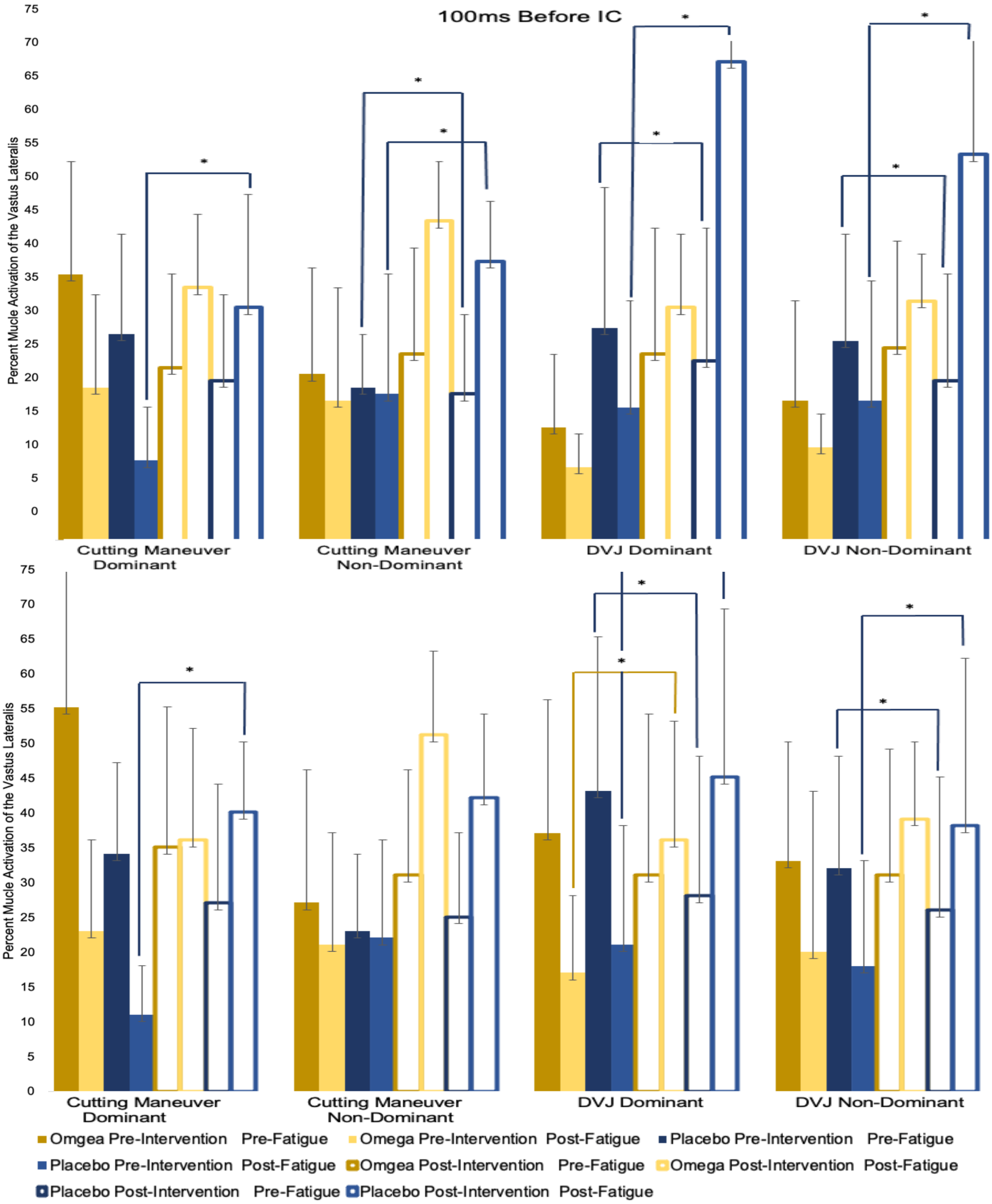

Figure 1 Activation Percentages of the VL 100ms and 50ms Before IC. *p≤0.05

DISCUSSION: Findings from this study suggest omega-3 supplementation had no impact on percent activation nor rate of activation of the BF at any time point. Significance was found in the omega-3 group 50ms before IC in the VL during the DVJ between pre and post-intervention fatigued conditions. No other significant findings were reported for VL in the omega-3 group. With most ACL ruptures occurring in the initial phase of landing (Dedinsky et al., 2017), although not significant, subtle group decreases in rate of muscle activation and group

increases in percent activation during weight acceptance, indicates individuals in the omega-3 group had more dynamic control of the knee in the fatigued conditions post-intervention, which could limit potentially harmful knee kinematics during high-risk movements, when compared to the placebo group. These trends suggest a possible adaptation occurring within the muscle spindles, golgi tendon organ (GTO), and joint proprioceptors in the commonly underactive hamstrings muscle group, in this study represented by BF (Mileusnic & Loeb, 2006;). It is speculated that no changes were observed in BF pre-activation due to external torques and forces having not been applied up the kinetic chain from vGRF or antagonistic muscles, therefore the GTO and joint proprioceptors had not sensed external forces requiring increased activation of the BF (Mileusnic & Loeb, 2006;). Nevertheless, before definitive conclusions can be drawn, future investigations should evaluate this further.
Increases in percent and rate of muscle activation in the placebo group between pre and post-intervention fatigued and non-fatigued conditions, 100ms and 50ms before IC, indicate a potential training adaptation which was not controlled for by the researchers. The timing of pre-testing was not controlled for; thus, although training volume did not change, training intensities may have fluctuated between pre and post-testing which could have impacted muscle activity. Favero and Stoll (2016) reported improvements in aerobic capacity from pre-season to post-season with the incorporation of one HIIT session per week. Individuals in the placebo group who began pre-testing in their off-season and over the intervention integrated HIIT sessions into their training program would be more resistant to fatigue, which could impact neuromuscular activation patterns. Limitations to this study include a small sample size, variation in learned movement mechanics across participants, and timing of pre and post-testing relative to competitive seasons.

CONCLUSION: This study found this dosage and duration of omega-3 supplementation had no impact on muscle activation patterns of the BF on either limb during dynamic tasks but increased VL activation 50ms before IC during a DVJ on the dominant limb, post intervention. Subtle changes in group means for BF activation in the omega-3 group indicate a potentially beneficial adaptation which should be explored further with a larger sample. Manipulation of duration and dosage could elicit further adaptations. Future research should evaluate the effect of omega-3 supplementation in conjunction with a training intervention to elicit greater adaptations which could further reduce the risk of ACL ruptures during dynamic tasks.

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