DOES POSTURAL STABILITY IMPROVE AFTER USING A NOVEL BIOMECHANICAL DEVICE IN RECREATIONAL FEMALE ATHLETES AT A HIGH RISK OF ANTERIOR CRUCIATE LIGAMENT INJURY?

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Anterior cruciate ligament (ACL) injury is one of the most debilitating knee injuries among young athletes. Mitigation of the risk factors (e.g., Postural Stability) through training is a key in reducing the risk of an ACL injury. AposTherapy (APOS) is a novel unstable foot-worn device which will introduce a perturbation with alignment re-adjustment to lower limb reducing dynamic loads on the knee joint. The purpose of this study was to investigate the biomechanical effect of APOS in recreational female athletes. Participants wore APOS only in walking group and with add exercise in walking and exercise group for a period of six weeks and were assessed afterwards. The study identified a significant improvement (p=0.001 and 0.03, respectively) in COP excursion in both study groups. Utilising foot-worn interventions (APOS) may be an efficient method for mitigating risk of ACL Injury.

KEYWORDS: ACL injury, Female Athletes, Neuromuscular Training, Postural Stability.

INTRODUCTION. ACL injury is one of the most serious knee injuries in young athletes (Shultz et al., 2015), which has both short- and long-term morbidity consequences and negative impact to wellbeing and health of the individuals (Gianotti et al., 2009). To a large extent postural stability assimilates somatosensory information to control the position of the center of mass (COM) in the base of support (BOS) (Shumway-Cook et al., 2012). The deviation of COM away from the BOS during dynamic athletic activities has been recognized by several authors as a factor of increasing loads on ACL that would increase the risk of non-contact ACL (NCACL) injury (Hewett et al., 2009). One of postural stability variables is the center of pressure (COP) excursion, which has been recognized as a critical risk factor for NCACL injury (Durall et al., 2011). Moreover, been reported a strong association between maximal knee valgus moments and CoP excursion (Durall et al., 2011).

Balance training has been proposed to improve the feedback of mechanoreceptors which may lead to sensorimotor integration and subsequently the adaptation of neuromuscular control reflected in alteration of muscle recruitment patterns (Zech et al., 2010). Many neuromuscular training (NMT) and prevention programmes have been introduced to reduce ACL injury risk (Sugimoto et al., 2016). However, the disparity between positive laboratory results demonstrating NMT programs and the actual effects on injury outcomes among high-risk female athlete’s population has exposed a missing link between the current published research and the prevention programs effectiveness (Sugimoto et al., 2016). Most of the NMT programs require a significant time commitment and a considerable level of complexity and intensity. This has appeared to deter athletes and reduced their compliance rates (Sugimoto et al., 2012), which has highlighted the demand for a simpler and more effective intervention.

APOS could manipulate knee alignment to reduce loads on the knee and at the same time introduce perturbation for motor learning (Haim et al., 2008). Evidence of APOS has been established in osteoarthritis management (Reichenbach, et al., 2020). Elzein et al. (2020) have demonstrated some promising outcomes after using the APOS, which indicated APOS could significantly improve dynamic knee valgus in recreational female athletes with a high ACL injury risk movement pattern. No study has examined whether APOS could alter postural stability measures in individuals at a risk of a NCACL injury. The purpose of this study was to investigate the effect of incorporating APOS alone or in combination with an exercise programme on postural stability in a group of young recreational female athletes.

METHODS: This was a pilot parallel group randomized controlled trial (Pilot RCT) study. The study population included 32 young adults' recreational female (Table 1). The study population was randomly located to three groups. There were 11 participants in the control group, 10 participants in the walking group and 11 in the walking exercise group. All participants provided informed consent, and the study was approved by Research Ethics Committee at the University of Salford. The study aimed to exam whether the introduction of perturbation training on knee alignment with APOS would improve postural stability when compared to the control group.

Table 1: Participants demographic data in Mean, standard deviation (SD)

Parameters	Control group	Walk group	Walk & Exercise group
Height	165.9±4.1 cm	167.0±3.19 cm	165.6±3.2 cm
Mass	63.8±4.08 kg	66.2± 5.11 kg	63.5± 4.15 kg
Age	24.5±5.47 years	26.5±3.69 years	28.0±3.67 years

2D VIDEO ASSESSMENT: Individuals who agreed to take part in the study were initially assessed using 2D analysis to assess the frontal plane projection angle (FPPA) of their non-dominant knee while performing a Single leg squat (SLS) task. In order to be eligible for the study, individuals had a knee valgus angle >8°on their non-dominant knee which was considered higher than the normative knee valgus angles reported (Mendonça et al., 2011). The dominant leg was defined as the leg that the participant used to kick a ball.

APOSTHERAPY CALIBRATION: APOS comprised of two modular elements attached onto fore- and rearfoot sole surface (Haim et al., 2008). The elements were attached to the forefoot and rear-foot regions of the shoes with two mounting rails which allowed for flexible positioning of each element (Haim et al., 2008). The APOS was calibrated by enforcing a biomechanical effect and neuromuscular control to simultaneously introduce perturbation through the creation of controlled micro-instability, which could challenge the dynamic stability of the lower limbs while modifying the chain of joints to its optimal alignment (Khoury et al., 2015). This would be as a result of placement and alignment of the elements under the foot especially at forefoot in the medial-lateral direction (Haim et al., 2008). All participants had their APOS specifically calibrated by the same senior technician (Apos, UK) (Figure 1) and were required to attend the laboratory for the baseline data collection.

Figure 1: Illustration of the calibration process.

The participants were randomly divided into three study groups: Group 1 was the walking with APOS only group with no additional exercises (W group). Group 2 was the walking with APOS plus daily 15-min exercise group (WE group). Group 3 was the control group that did not use APOS and continued their routine training program (Control group). The participants in Group 1 and 2 were asked to wear the APOS device for a minimum of one hour per day during typical walking activities in the home and attended the gait laboratory twice at baseline and after a six-week intervention period. Postural stability was assessed during the Single Leg Stance (SLs).

The SLs test consisted of five trials while standing on single leg on the force plate to determine the anterior-posterior and medial-lateral excursion of the centre of pressure (CoP). The force platform data exported into V3D. The balance was quantified using excursion of CoP on a force plate, which was presented by the range of motion in medial-lateral (ML) and anterior–posterior (AP) direction. The total CoP excursion was calculated based on x (anterior–posterior)-y (medial–lateral) average range (Excel, Microsoft, USA). The formula for the calculation of the resultant CoP excursion E_{COP} should be: $E_{COP} = \sqrt{((x_{i+1} - x_i)^2 + (y_{i+1} - y_i)^2)}$, Where x_i, y_i are the coordinates of the COP at the frame *i* of the SLs stance phase normalised to100%.

An assessment of normal distribution was checked with a Shapiro-Wilk test and by visual inspection of boxplots. Mean ± standard deviation for all measured variables was calculated. To determine the differences between the study groups the factorial repeated measures ANOVA (3x2 Factorial ANOVA mixed between-within) for parametric data or Friedman test for non-parametric was performed. Post hoc analyses were subsequently performed using the Bonferroni multiple comparison procedure to evaluate significant groups to time interactions were conducted. Effect size(d) was calculated to indicate the magnitude of change in case both intervention groups showed significant changes in the dependent variable assessment. The Cohen's d values were used to calculate the effect size ($d = \frac{Xi - Xv}{SDc}$) of each of the study intervention groups. Statistical significance was set at ($p<0.05$). All statistical analysis was performed in SPSS (Version 26.0. IBM SPSS Statistics, USA).

RESULTS. There were no statistical differences between any of the two groups in terms of age, body mass and height ($P>0.05$). The W and WE group COP-Excursion during SLs task showed a significant reduction from baseline after 6 weeks APOS intervention (Table 2).

Table 2: The mean, standard deviation (SD) and the mean difference (Mean diff.) of the CoP-Excursion values for SLs (Single leg Stance) in three study groups at the pre & post intervention.

Task	CoP-Excursion			
SLs	**Mean± SD**	**Mean Diff± SD**	**p**	**Effect size**
Control group Pre	45.09±27.63 mm	9.43±30.97 mm	0.19	
Control group Post	35.63±13.35 mm			
W group Pre	73.16±42.57 mm	55.21±37.85 mm	0.001	1.24
W group Post	17.95±8.03 mm			
WE group Pre	41.81±30.56 mm	22.18±29.14 mm	0.03	0.51
WE group Post	19.63±7.79 mm			

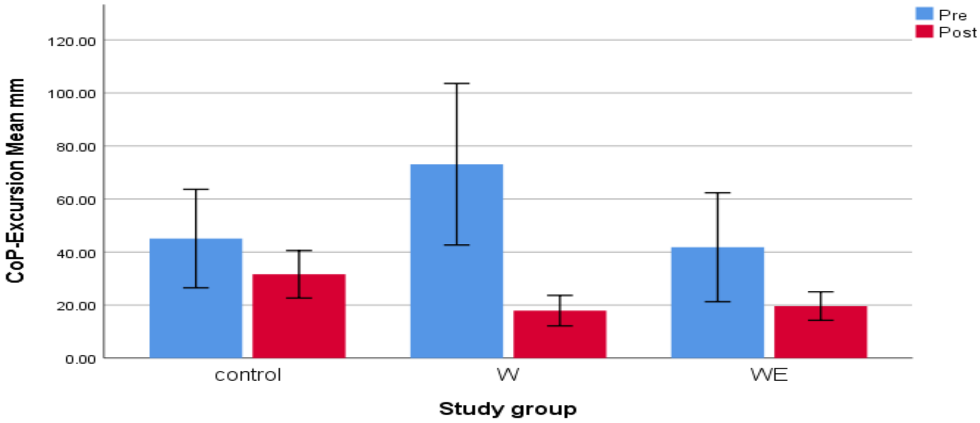

Figure 2: The CoP-Excursion of pre-(Blue) and post-treatment (Red) for Single Leg Stance task.

DISCUSSION. APOS device showed the potential to improve postural stability. This was demonstrated by a significant reduction observed in CoP-excursion at post-treatment assessment in both intervention groups. Since the effect size of the walking group (d= 1.24) was larger than the effect size of the walking and exercise group (d=0.51), APOS showed more significant effect on the W group based on criteria by Cohen et al. (1988).

The outcomes of the walking group in the current study may suggest it is possible to adopt a low impact intervention by just using APOS while walking during daily activities. The convex shape of the elements puts participants in a state of perturbation by having the participant walk with a device every day thereby considered to induce neuromuscular adaption towards the desired neuromuscular gait pattern (Bar-Ziv et al., 2013). The easy and simple way of using the APOS can promote its use and achieve good compliance and effect. APOS as a more time efficient intervention could help the individuals achieve the required neuromuscular control enhancement effect.

CONCLUSION: The time demand and complexity can be daunting for athletes and coaches implementing NMT programmes. The outcomes of this study demonstrated the potentials of the APOS to functionally improve postural stability. A significant improvement in postural stability as identified and could present a time efficient and effective ACL injury mitigation intervention method, which would be easy to incorporate around the busy schedule of high-risk female athlete's population. However, future studies would be recommended to observe the wash out effect and to follow the participants throughout the season.

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