CAN WE ALTER YOUTH ATHLETE'S LANDING STRATEGY IN A STOP-JUMP MOVEMENT?

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The purpose of this study was to determine the effect of four different neuromuscular training programs on the kinematic landing patterns of pre-elite youth athletes during a stop-jump movement. Eighty-nine pre-elite youth athletes from the Western Region Academy of Sports Basketball, Netball, Softball, Triathlon and Field Hockey squads were recruited for biomechanical analysis before and after the completion of one of four randomly assigned 12-week training intervention programs, in conjunction with a strength and conditioning program. Results of this study identify youth athletes with poor movement competency acquire similar alterations in their kinematic landing pattern regardless of the type of training intervention completed, with no significant interaction identified between training groups, identifying that a basic strength and conditioning program can implemented to alter landing technique in a stop-jump task.

KEYWORDS: landing, neuromuscular training, stop-jump, youth athletes.

INTRODUCTION: With the substantial and devastating cost of injuries among the sporting population, neuromuscular training programs are a commonly utilised tool for the prevention of lower limb sporting injuries (Hewett, Lindenfeld, Riccobene, & Noyes, 1999). Many of these programs have been implemented within a late adolescent or adult population (Chappell & Limpisvasti, 2008) despite research suggesting that adolescents are in a key development phase for implementation of landing retraining injury prevention strategies (Myer et al., 2011). Dynamic neuromuscular training has been reported to be effective for improving lower limb movement biomechanics among adolescent females and in turn, decreasing injury risk (Myer, Ford, Palumbo, & Hewett, 2005), suggesting that this population can be successfully re-trained to land correctly during dynamic landing tasks. However, many of the current neuromuscular retraining programs are performed in controlled environments such as supervised gyms and require specialised equipment, such as trampolines (Hewett et al., 1999) or wobbleboards (Myklebust et al., 2003). This can create access issues, especially in rural regions where access to formal sporting structures and support mechanisms are limited.

A key focus of neuromuscular prevention programs has been to alter landing technique such as resultant symptoms (e.g. knee abduction angles) (Myer et al., 2005), primarily focusing on the eccentric loading phase of a jump-landing task (Boden, Dean, Feagin, & Garrett, 2000). However, the focus on specific joints (e.g. the knee joint for ACL injuries) and symptoms (e.g. increased knee valgus in ACL injuries) in an attempt to prevent lower limb injuries has not been effective, as evidenced through high rates of injury and re-injury (Mottram & Comerford, 2008). A broader focus on the entire kinetic chain might therefore be warranted, as the lower extremities attach to the lumbopelvic region and as a result of the closed-kinetic chain nature of sporting activities. While researchers have successfully retrained athletes landing patterns utilising a kinetic chain focus, many of these programs have been implemented within a late adolescent or adult population (Chappell & Limpisvasti, 2008). Therefore, the purpose of this study was to compare the effects of four different 12-week intervention programs on the results of a full biomechanical analysis during a stop-jump landing tasks in pre-elite youth athletes in a rural region.

METHODS: Of the 89 pre-elite youth athletes (15.2±2.2 years, 171.1±9.4 cm; 61.9±12.3 kg), with no sign or symptoms of injury recruited from the Western Region Academy of Sport Basketball, Hockey, Netball, Triathlon and Softball teams, 67 completed the entire study protocol. Participants were required to complete five successful stop-jump movements, which was defined a participant obtaining an adequate approach speed of between 3.5 and 4.5 $m{\cdot}s^{-1}$ during the horizontal preparation phase, placing one foot wholly on each force platform, and contacting the ball suspended from the ceiling with both hands. During each trial, the ground reaction forces generated at landing were recorded (2500 Hz) using two multichannel force platforms with built-in charge amplifier (Kistler, Winterthur, Switzerland) embedded in the floor and connected to control units (Kistler, Winterthur, Switzerland). Participant's three-dimensional lower limb and trunk motion was recorded (250 Hz) using a Qualisys Oqus 300 camera system (Qualisys AB, Göteborg, Sweden). Passive reflective markers were placed on each participant's lower limbs, pelvis and torso. This biomechanical analysis was performed before and after the completion of a 12-week intervention program. Athletes all completed a strength and conditioning program that encompassed a dynamic warm up, a push, pull, squat and lunge resistance exercise and cool down stretches. Athletes were additionally divided into one of four groups including core (range of functional balance and postural stability core exercises designed to improve lumbopelvic stability), landing retraining (basic strength, stability and plyometric exercises in attempt to re-train the landing technique), core and landing retraining, or control (no additional training).

Data Analysis: Analyses of the kinematic data were performed using Visual 3D software (Version 3, C-Motion, Maryland, USA) in accordance with methods of Mann, Edwards, Drinkwater, and Bird (2013). A series of mixed-design factorial analysis of variance (ANOVA) were performed with primary interest in the independent factor of the effect of the intervention and secondary on the pre/post measures. There were four factors for analyses of joint angles (intervention*pre/post*events*angles). Time events comprised five levels; the discrete vertical ground reaction force (F_V) time-points within the stance phase of the cut (initial foot-ground contact (IC), F_{V1}, F_{V2}, F_{V3}, take-off (TO)), while angles comprised of 18 levels; six joints (ankle, knee hip, L5S1, T12L1, thorax-pelvis) in three respective planes (x,y,z). Partial eta squared was utilised to calculate effect sizes for all interaction for the repeated measures ANOVAs. Effects sizes (η^2) were defined as trivial (<0.0099), small (0.0099-0.0588), moderate (0.0588-0.1379), and large (>0.1379) sizes (Richardson, 2011).

RESULTS: Joint angles showed no significant main effect of intervention during landing ($F_{3,62}$=0.23, p=0.88, η^2=0.0109) or pre/post ($F_{1,62}$=0.18, p=0.67, η^2=0.0029). However significant interactions between pre/post*events ($F_{4,248}$=4.10, p=0.003, η^2=0.0620), pre/post*angles ($F_{17,1054}$=3.71, p<0.001, η^2=0.0565) and pre/post*events*angles ($F_{68,4216}$=2.04, p<0.001, η^2=0.0318) were present. *Post h*oc tests failed to identify the source of the significance in pre/post*events yet revealed that from pre- to post-intervention, the grand mean across all events was greater for L5S1 extension (pre=11.8±1.1°; post=1.3±0.9°; p<0.01) and thoracic-abdominal (pre=7.2±1.0°; post= 4.2±0.9°; p<0.05) joint angles pre-compared to post-intervention. Comparing pre- to post-intervention, a significant reduction in hip flexion at IC (p<0.001), F_{V1} (p<0.001); thoracic abdominal flexion at all events (p<0.001); T12L1 rotation at F_{V1} (p<0.05); hip external rotation at F_{V3} (p<0.01) and increased L5S1 flexion at all events (p<0.001).

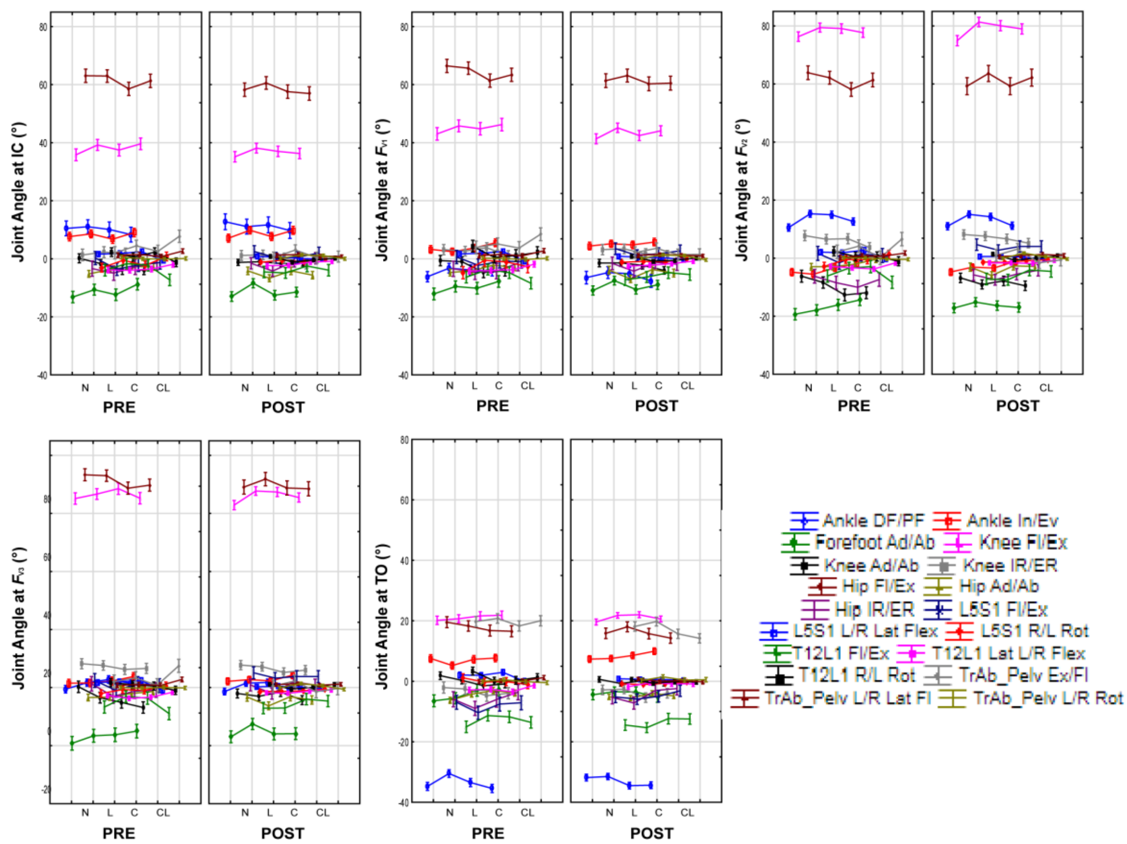

Figure 1: Mean ± standard error (SE) for joint angles (°) pre- and post-intervention during the stop-jump task for four intervention groups (No additional training (N), Core (C), Landing (L) and Core+Landing (CL)).

DISCUSSION: The current study is the first to compare the effects of three different field based injury prevention programs on the landing biomechanics during a stop-jump movement among pre-elite youth athletes. Results revealed no significant differences between the interventions, however a significant change in stop-jump landing mechanics were identified between following the 12-week intervention. Specifically, all youth athletes, regardless of training intervention group, landed with a more neutral trunk relative to pelvis position in post-intervention testing. Neuromuscular training often elicits a training effect that is commonly identified in strength interventions (Sale, 1988), whereby neuromuscular activation patterns become more succinct leading to an improved performance (Sale, 1988). Thus, the altered movement pattern between pre- and post-intervention is likely related to an increase in neuromuscular control as a result of general training rather than any specific intervention. While this neutral landing posture in itself has been suggested to be an ACL injury risk factor (Griffin et al., 2000), the present study did not observe any other ACL landing risk factors associated with this landing strategy. That is, no indications of lower knee flexion at IC or greater peak knee abduction during landing, were observed, which have been defined as key kinematic injury factors (Shimokochi, Ambegaonkar, Meyer, Lee, & Shultz, 2013). It is possible that the youth athletes here, most of whom commenced the program with poor movement competency, were attempting to modify their landing strategy by adopting a ‘guarding’ (van der Hulst, Vollenbroek-Hutten, Rietman, & Hermens, 2010) or ‘splinting’ (Arendt-Nielsen, Graven-Nielsen, Svarrer, & Svensson, 1996) technique. While a universal definition of this phenomenon does not exist in the literature (van der Hulst et al., 2010), it has been characterised by a general increase in muscular tension, specifically increased activation of the superficial core musculature, and has been related to lower back pain (Arendt-Nielsen et al., 1996). Adopting a ‘guarding’ technique, landing in a more neutral position by reducing trunk relative to pelvis flexion and rotation, may have been an attempt by the participants to control their body segment stability and thus reduced their degrees of freedom, i.e. the complexity of the task (Wang, O'Dwyer, & Halaki, 2013), during the landing phase of a dynamic movement.

CONCLUSION: Results indicated that regardless of intervention, all athletes displayed similar post-intervention results, suggesting that a simple strength and conditioning program, as opposed to a more complex intervention program, can be implemented in pre-elite youth athletes with poor movement competency to provide changes in landing patterns. While it is unknown whether the splinting or guarding strategy implemented by athletes is beneficial or detrimental, longitudinal research is required to determine whether this approach is maintained or just the first phase of learning to land in a more controlled manner.

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ACKNOWLEDGEMENTS: The authors gratefully acknowledge the Western Region Academy of Sport for providing the participant pool from which participants were recruited for this study.