EFFECTS OF TRAINING ON ANKLE MECHANICS DURING DROP LANDINGS

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SUMMARY
This randomised controlled trial investigated the effects of static stretching, eccentric strength training and task-specific landing training on plantar-flexor flexibility and strength, and on ankle biomechanics during a landing task. Results demonstrated that static stretching was most effective at increasing dorsiflexion range of motion (ROM) and may also be effective in reducing plantar-flexor strain during landings. No change in ankle biomechanics was observed in the control and eccentric strength training groups; although task-specific landing training improved muscular coordination and increased load absorption time during landings. Stretch and landing training may each be effective methods for decreasing plantar-flexor injury risk in sports involving landing movements, albeit via different mechanisms.

INTRODUCTION
Evidence suggests that a decreased dorsiflexion ROM is associated with increased ankle and plantar-flexor muscle-tendon unit (MTU) injury risk during sports involving landings [1-3]. Training programs designed to increase dorsiflexion ROM may therefore improve landing biomechanics and, in turn, decrease injury risk, although the optimal and most efficient type of training to achieve such adaption in athletes engaged in landing sports is yet to be established. Therefore, the purpose of this study was to initially determine whether a task-specific drop landing training program would have the same effect on dorsiflexion ROM as isolated stretching or eccentric strength training. The primary purpose was then to determine the effects of static stretch training, eccentric strength training and task-specific drop landing training on ankle biomechanics during a drop landing task.

METHODS
Passive dorsiflexion ROM (DROM), plantar-flexor stiffness and eccentric plantar-flexor strength were assessed in 45 male volunteers (Table 1) before and after a 6-week training intervention using a randomised controlled trial study design. Passive weight-bearing DROM was measured with the knee in flexion and extension, using a standing lunge test [4]. Plantar-flexor stiffness was determined by measuring the slope of the torque-angle curve between 15° and 20°, generated while passively stretching the plantar-flexors at $5°.s^{-1}$ [5], and using a KinCom dynamometer. Eccentric plantar-flexor strength ($30°.s^{-1}$ and $180°.s^{-1}$) was also measured using the KinCom dynamometer.

During the baseline and post-intervention testing sessions, three-dimensional ankle joint kinematics were quantified using an Opto*TRAK* 3020 motion analysis system, while the participants performed 5 single limb drop landings onto a Kistler force platform at a vertical descent velocity of 3.21 ± 0.17 $m.s^{-1}$. During each drop landing, muscular activity was also sampled from four shank muscles (tibialis anterior (TA), soleus (SO), gastrocnemius medialis (MG) and gastrocnemius lateralis (LG)). Achilles tendon forces during each landing were then calculated by dividing the internal plantar-flexor moment by the Achilles tendon moment arm [6].

Participants were randomly allocated to a control group or one of three experimental training groups: static stretching [7], eccentric strength training (conducted using the KinCom dynamometer) or a task-specific drop landing training. A two-way ANOVA (assessment day x training group) was then used to assess the effects of training on DROM, plantar-flexor stiffness, eccentric plantar-flexor strength and all outcome variables characterising muscular activity, ankle kinematics and forces generated during landings ($p < 0.05$). Where significant interactions or significant main effects were found, *post hoc t*-tests were performed ($p < 0.05$).

Table 1: Mean (± SD) data for participants in the experimental training and control groups.

Training group	n	Height (cm)	Mass (kg)	Age (yr)
Stretch	10	183.7 (7.2)	76.4 (9.1)	21.4 (5.1)
Strength	12	177.6 (5.2)	72.9 (8.4)	21.9 (4.0)
Landing	11	182.3 (6.9)	71.9 (13.0)	21.8 (3.0)
Control	12	179.1 (8.5)	76.8 (10.3)	24.2 (6.2)

RESULTS AND DISCUSSION
Passive DROM significantly increased in the stretch (6° ± 4°; 15% increase; $p = 0.003$) and eccentric strength training (2° ± 3°; 6% increase; $p = 0.035$) groups post-intervention, with no change found in the landing or control groups. Passive plantar-flexor stiffness did not change in any group post-intervention, whereas eccentric strength increased significantly in the control, strength and landing training groups, although the increase was greatest in the eccentric strength training group.

Post-intervention, participants in the drop landing training group displayed earlier peak activity of the lateral gastrocnemius muscle (-59 ± 135 ms; group-day interaction: *p*

= 0.014; Figure 1), were significantly more plantar flexed at initial foot-ground contact (~4°; group-day interaction; p = 0.032) and took more time to dissipate landing loads relative to participants in the other training groups. This was in contrast to the other training groups where landing time decreased (group-day interaction; p = 0.040; Figure 2). The earlier peak in lateral gastrocnemius activity in the landing training group coincided with the peak activation of medial gastrocnemius, which may be a favourable neuromuscular adaptation in terms of absorbing peak loads.

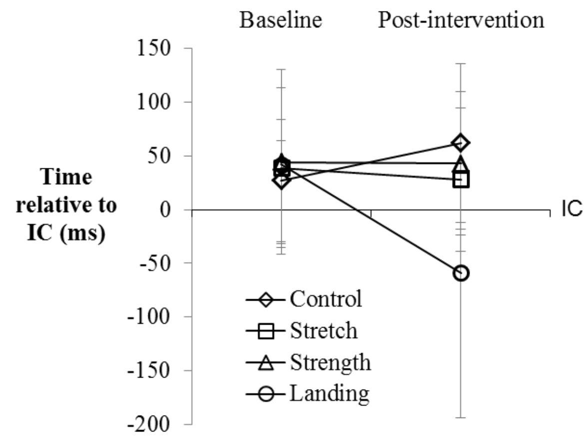

Figure 1: Effect of training on the timing of peak lateral gastrocnemius muscular activity relative to initial foot-ground contact (IC).

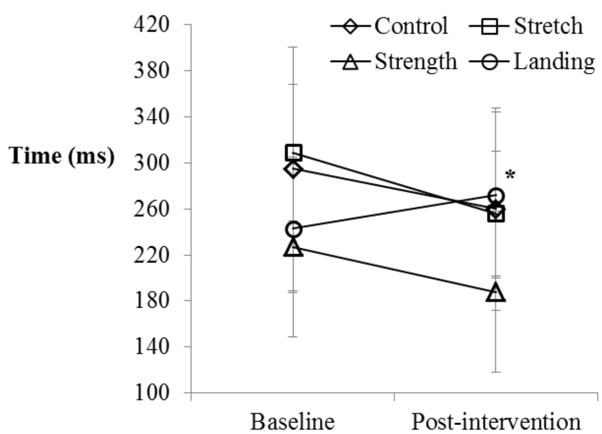

Figure 2: Effect of training on the length of time taken to absorb the landing load during ankle dorsiflexion. * = significant increase by the landing training group post-intervention ($p < 0.05$).

The stretch group displayed significantly less peak dorsiflexion during the drop landing task, despite the significantly greater DROM available, and consequently used a significantly lower percentage of their available DROM to achieve their peak landing dorsiflexion angle (Figure 3). This finding suggests that the stretch training group may have experienced less strain to their plantar-flexor MTU during the landing task. Conversely, the landing biomechanics of the control and eccentric strength training groups did not significantly change post-intervention. It is postulated, therefore, that task-specific drop landing training and static plantar-flexor stretching may each be effective methods for reducing injury risk by reducing the magnitude of stress or strain encountered by the plantar-flexor MTU during landings, respectively. Further research is required, however, to determine the efficacy of these training interventions in decreasing injury rates in landing athletes.

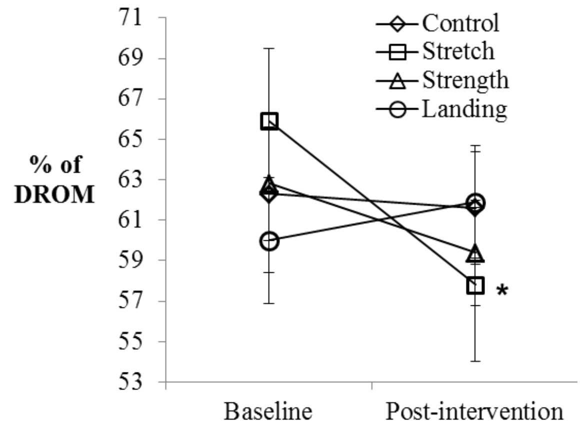

Figure 3: Effect of training on the percentage of passive DROM achieved at peak dorsiflexion during drop landings. * = significant decrease by the stretch training group post-intervention ($p < 0.05$).

CONCLUSIONS

Static stretch training was the most effective method for increasing DROM and may be useful for athletes whose sports involve dynamic landings, by reducing plantar-flexor MTU strain, without causing substantial changes to landing technique. Task-specific drop landing training may also be beneficial for injury prevention for athletes involved in landing sports by improving their muscular coordination and increasing load absorption time.

ACKNOWLEDGEMENTS

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REFERENCES

1. Flood L & Harrison JE, *Medical Journal of Australia*. **190** : 87-90, 2009.
2. Pope R, et al., *Australian Journal of Physiotherapy*. **44**: 165-177, 1998.
3. Rees JD, et al., *The American Journal of Sports Medicine*. **37**: 1855-1867, 2009.
4. Bennell K, et al., *Australian Journal of Physiotherapy*. **44**: 175-180, 1998.
5. Kubo K, et al., *European Journal of Applied Physiology*. **85**: 226-232, 2001.
6. Self BP & Paine D, *Medicine & Science in Sports & Exercise*. **33**: 1338-44, 2001.
7. Guissard N& Duchateau J, *Muscle & Nerve*. **29**: 248-55, 2004.