THE IMMDIATE EFFECT OF A GENTLE HEEL STRIKE ON PERONEAL MUSCLE PRE-LANDING ACTIVATION DURING PROLONGED TREADMILL RUNNING IN MALES

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Ankle sprains are common in runners. Inactive peroneal longus (PL) is one of the main contributors. The aim of this project was to study the immediate effect of running with a gentle heel strike (GHS) on pre-landing activation of the PL. It was hypothesised that GHS would pre-activate the PL to a greater extent. 11 healthy participants partook in two separate trials. The first involved running on a force plate treadmill with normally, the second with ~70% of mean heel pressure (MHP). GHS showed higher pre-landing PL activated level. There was data showing significant differences between groups at multiple timepoints. The present study showed that running with ~70% MHP compared with 100% increased PL activation for pre-landing phases. Further study should be implemented to see the fatigue level of PL during pro-longed running when running gently.

KEYWORDS: running, ankle sprain, landing, muscle activation.

INTRODUCTION: The population of recreational runners increased drastically from the 1970s with a steady increase in running events and competitions (Fields et al. 2010). The incidence of lower extremity running injuries ranged from 19.4 % to 79.3 % (Van Gent et al. 2007). Ankle sprains are a common injury among recreational runners (Tenforde, Yin, and Hunt 2016). LAS account for 14 % of all sport related Emergency Department visit and 3 % to 5 % of all visits in the UK (Fong et al. 2008)(Cooke et al. 2003). Lateral ankle sprain (LAS) occurs with plantarflexion and inversion of the foot, coupled with internal rotation. One of the aetiologies of LAS is the delayed reaction time of the peroneal muscles – PL and peroneal brevis (PB) (Fong et al. 2009). The inactive peroneal muscles at foot strike is one of the main contributors to LAS, with the peroneus longus being a primary stabiliser of the forefoot during the gait cycle (Chen et al. 2015), thus studying its activation is a path to prevent injury. Muscle activation patterns can be altered through a change of running technique. Gait retraining, utilising non-invasive methods (Eng and Tang 2007), can be effective in altering the gait of healthy participants. Biofeedback, which include visual, auditory, and haptic methods gives biological information to the user, may be the easiest method to successfully implement. The hypothesis of this study was: 1. During running, GHS reduces MHP. 2.GHS increases PL activation level.

METHODS: Eleven male students (Age 24.1 ± 1.8 y; Height 1.8 ± 0.1 m; Weight 75.6 ± 5.0 kg) volunteered for the study. All participants were healthy, with no prior detrimental injury to the lower extremity that would have affected the trial. They had running experience (e.g., football, basketball, recreational running, etc.), with a range of running levels between them. Participants were asked not to perform strenuous activation within 48 hours of each trial, reporting to the laboratory for two trials approximately one week apart. They were also asked to wear the same running shoes in each trial to make measurements consistent.
Two 30-minute trials were conducted with each participant, running on a treadmill at their self-defined comfortable pace (8.4 ± 0.7 km/h). Both trials had an identical set-up, with analysis performed on each leg. Markers were placed on the lower extremity: lateral and medial aspects of the femoral epicondyle, lateral and medial aspects of the malleolus, the heads of the first and fifth metatarsal, the tip of the first distal phalanx and the heel. The markers were initially attached with a double-sided tape, then reinforced with a mesh tape (Self Adhesive Tape, Hypafix®, Hamburg, Germany) Superficial PL muscle boarders were found through muscular palpitation (ankle eversion). The area for each electrode to be positioned on the PL was at 25% from the fibula head to the lateral malleolus, orientated parallel to the muscle fibre direction, as described in the Surface Electromyography for the Non-Invasive Assessment of

Muscles (SENIAM) guidelines (Hermens et al. 2000). Before electrode placement, the skin was prepared – all hair on the target area was shaved, then flaky skin was removed carefully with abrasive tape (Red Dot Trace Prep Tape, 3MTM, Canada). The area was then wiped with an alcohol pad to remove oils, reducing the noise of the EMG signal (Vaiman and Eviatar 2009). After the electrodes were placed, a sweat proof tape (Waterproof Film, Wordmouk, China) was attached to the skin either side of the electrodes, with the mesh tape spreading over the electrode and onto each piece of sweat proof tape – this ensured a reduction of motion artefacts, also encouraging consistent contact between skin and EMG(Li, Wang, and Huang 2020). Appropriately sized insoles, as part of the pressure measurement system, were fitted to the participant's shoes. After the main hardware and battery of the system ware attached to the participant via a running backpack, the wiring of the system was then reinforced at the ankle and knee via elastic bandages as suggested by (Konrad 2005) - this reduces the potential of damage to the system and causes less interference with the participant. The first trial involved running with natural running form. In the second trial, participants were instructed to run with ~70% of the MHP recorded in the first trial - during the warmup period, biofeedback was given to participants in the form of vocal cues, guiding them to the correct heel pressure, using the foot pressure system. Data was recorded for ~30 seconds every five minutes, starting from the beginning of each trial up until the 30-minute mark – there were seven separate time points. At each time point the participant was asked to step off the treadmill momentarily, so the MHP data could be synchronised with other data.

To measure pre-landing activation, EMG signals from the PL were trimmed for the period of pre-landing (100 ms pre-IC to IC)(Li et al. 2019). This data was then filtered using a Butterworth bandpass filter (20-450 Hz), then full wave rectified, and low pass filtered at a cut-off frequency of determined through analysis, matching cut-off frequencies found in literature (Rose 2012) to generate a linear envelope (Li et al. 2019). The RMS of this data was taken to quantify the activity over the described time frames. This was done for 10 consecutive gait cycles, finding the average value. The subsequent frequency values were normalised to the maximum voluntary contraction (MVC) during the running trial (defined as the RMS from 50 ms pre-peak to 50 ms post-peak).

With all data normally distributed, a two-way multivariate analysis of variance (group × time) with repeated measures (MANOVA) was performed on processed EMG data recorded from the peroneal muscle to see any significant effects of group by time. If an interactive effect of group and time was discovered, a stratified analysis of variance (ANOVA) was utilised to show the effect of time on each group, with Tukey pairwise comparisons conducted between 0 minutes and every other time-point. If no interactive effect was found, an ANOVA was conducted on each main effect. Paired t-tests were also performed to show any significance between parameters at each timepoint. The level of significance was set to $p = 0.05$. All statistical analyses were conducted through SPSSTM (IBM Corporation, Armonk, NY, USA). Some data had to be omitted before statistical analysis when erroneous values were observed.

RESULTS: Looking at the differences between trials' pre-landing activation at each timepoint, a general trend of a greater pre landing activation can be seen for the 70% MHP trail in Table 1, however, significance can only be seen at 0 and 15 minutes ($p \leqslant 0.049$). Also. we can notice that during prolonged running, the differences between 70 % MHP and 100 % MHP PL pre-landing activation dropped. From 13.8 at 0 Minute and 8.2 at 30 minutes. The effect size was large (>0.55) among all timepoint.

Table 1. *EMG RMS values for pre-activation of the PL as a percentage of MVC ('*' indicates significance)*

	0 Min	5 Min	10 Min	15 Min	20 Min	25 Min	30 Min
R-RMS(100%)	14.1±12.0	13.7±11.4	14.1±11.2	15.5±10.0	13.0±10.6	15.8±10.8	19.2±11.9
R-RMS(70%)	27.9±18.3	23.8±19.0	24.5±19.9	26.6±18.8	24.5±16.5	26.8±17.8	27.4±17.3
Effect size	0.89	0.64	0.64	0.73	0.82	0.74	0.55
p-value	0.026*	0.128	0.117	0.049*	0.053	0.053	0.192

DISCUSSION: This study's purpose was to investigate whether running with gentler heel strike influenced PL activation during prolonged treadmill running. The PL was chosen due to its activation opposing the mechanism of LAS (Fong et al. 2009). The auditory method of biofeedback was used in the second trial, instructing participants on their MHP. A notable increase in average pre-landing activation was seen between the first and second trials, though with no significant group effect due to a large standard deviation in some timepoints. In the beginning and 15 minutes timepoint we can see a significant increasement of PL activation. Increased pre-landing activation levels were expected - PL activation rises with increased plantar flexion. There is a greater increase in pre-landing activation due to a plantar flexion initiated prior to foot contact with a gentler heel strike.
During prolonged running, the differences of PL landing-activation in two running conditions decreased. The reason under that might be not sufficient training effect and muscle fatigue. Still, further research should be conducted to clarify the mechanism behind this.
Running with a reduced MHP could have positive effects in the mitigation of LAS. Though this study proved to have insignificant effects for pre-landing activation between the two conditions. An overall decrease has been observed.

CONCLUSION: To conclude, the aims of this study were met with hypotheses confirmed to an extent. The study showed that running with ~70 % MHP compared with 100 % increased PL Pre-landing activation level, however, not significantly due to a large standard deviation of results. It can be speculated that running with a gentler heel strike may help prevent the mechanism of LAS, however further studies should be implemented to see the effects of this study on those with chronic ankle instability (CAI) and previous ankle sprain – these populations have altered PL recruitment.

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