Journal of Science and Medicine in Sport 19 (2016) 288–292

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams

Original research

Retraining running gait to reduce tibial loads with clinician or accelerometry guided feedback

Mark W. Creaby[a,*], Melinda M. Franettovich Smith[b]

[a] School of Exercise Science, Australian Catholic University, Australia
[b] Centre for Musculoskeletal Research, Mary MacKillop Institute for Health Research, Australian Catholic University, Australia

ARTICLE INFO

Article history:
Received 10 December 2014
Received in revised form 28 March 2015
Accepted 8 May 2015
Available online 15 May 2015

Keywords:
Acceleration
Biofeedback
Psychology
Biomechanics
Fractures
Stress

ABSTRACT

Objectives: Reducing tibial acceleration through gait retraining is thought to reduce the risk of stress fracture development, however current approaches require the use of advanced accelerometry equipment not readily available in the clinical setting. The aim was to compare the effect of clinician guided feedback with accelerometry guided feedback on peak tibial accelerations during running.
Design: Repeated measures randomised design.
Methods: Twenty-two healthy male runners were randomised to receive either tibial accelerometry or clinician guided feedback. Peak tibial accelerations were obtained for all participants (i) prior to intervention, (ii) after 10 min of feedback, (iii) after a further 10 min without feedback, and (iv) 1 week later.
Results: Across groups, significant reductions in peak tibial acceleration were observed from baseline to each of the subsequent time points in the order of 19–29% ($p = 0.001$). No between-group differences in peak tibial acceleration were observed at any of the follow-up time points ($p = 0.434$).
Conclusions: These data indicate that in the short term the low cost, low technology, clinician guided approach to retraining running gait may be equally as effective as the more expensive accelerometry guided solution in reducing peak tibial accelerations. Longer term follow-up is required to evaluate the efficacy of both approaches in reducing the risk of stress fracture development.

1. Introduction

Lower limb stress fractures are a common injury among runners, with incidence ranging from 3% to more than 20%.[1,2] Tibial stress fractures specifically, are frequently reported to account for 20.1–49% of all stress fractures in runners.[3,4] The relatively high incidence rate of this injury is further compounded by typical recovery times of up to 14 weeks[5] and a recurrence rate of up to 36%.[6,7]

Given the relatively high incidence and long recovery times associated with tibial stress fracture, knowledge of the modifiable risk factors for tibial stress fracture would be beneficial. Prospective evidence of risk factors for tibial stress fracture indicates that characteristics of running gait influence the risk of tibial stress fracture development. Specifically, female runners that exhibited higher tibial peak positive acceleration (PPA) during the impact phase of running gait were more likely to develop tibial stress fracture injuries.[8,9] This is supported by retrospective findings of higher tibial PPA in runners with a history of tibial stress fracture injury.[10]

Recent evidence indicates that reductions in tibial PPA can be achieved in those at high risk of tibial stress fracture development.[11] Using real-time visual biofeedback of their tibial acceleration, with instructions to make their footfalls quieter and "run softer", a group of runners with tibial PPA of above 8 g were able to achieve an ~50% reduction in peak accelerations following eight "retraining" sessions spread over a two week period.[11] Further, studies of the immediate effects of gait retraining with either visual or auditory feedback derived from tibial PPA indicate that significant reductions in tibial PPA can be achieved following as little as 5 min of feedback.[12,13] In light of these promising findings, a clinically feasible approach for the delivery of biofeedback would likely assist with the widespread use of this intervention.

The use of quantitative tibial accelerometry to provide real-time biofeedback is possible with the technology that is currently available: it is typically measured with the use of a small (<1 cm^3), lightweight (<10 g) device mounted to the surface of the skin over the medial tibial border, and accelerometry data can be collected and displayed in real-time using commercially available software.

* Corresponding author.
E-mail address: mark.creaby@acu.edu.au (M.W. Creaby).

http://dx.doi.org/10.1016/j.jsams.2015.05.003
1440-2440/

The clinical feasibility of quantitative tibial accelerometry is limited however by the cost of the technology and expertise required to parse and export the resulting data. Verbal instruction and feedback from a clinician or coach has been shown to be effective in reducing impact forces associated with jump landings,[14,15] and may be equally as effective as the quantitative technology based equivalent. For example, whilst real-time feedback regarding three-dimensional hip kinematics has been shown to be an effective approach to retrain running kinematics,[16] a mirror appears to be similarly effective.[17] Qualitative feedback regarding running mechanics that may be indicative of tibial accelerations may be achievable with simple verbal cues from a clinician such as "run softer" and "make your footfalls quieter". It is not known if this clinician guided, qualitative feedback approach can achieve reductions in tibial accelerations, and indeed if it is as effective as quantitative tibial accelerometry feedback.

Therefore the purpose of this study was to compare the short-term changes in tibial PPA between clinician guided feedback delivered with the use of verbal cues and tibial accelerometry guided feedback delivered with the use of real-time visual display of these data. We hypothesised (i) that tibial PPA would be reduced following both the clinician and tibial accelerometry guided feedback approaches, and (ii) that the change in tibial PPA following feedback would not differ between the clinician and tibial accelerometry guided feedback approaches.

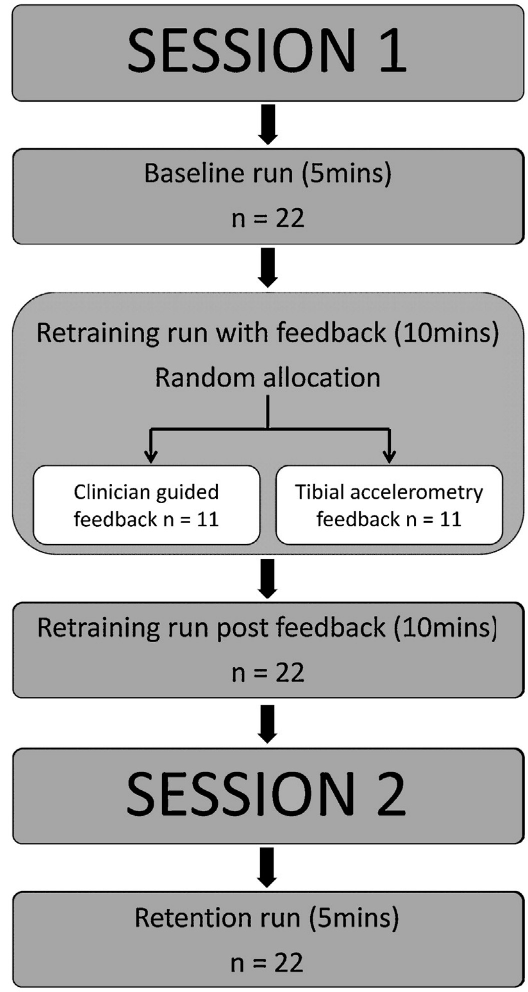

Fig. 1. Flow chart of study protocol. All study participants completed two data collection sessions in the same order, with a 7 or 8 days gap between the two sessions.

2. Methods

Twenty-two healthy males were recruited to take part in the study. The inclusion criteria were: (i) male; (ii) aged 18–45 years; (iii) run greater than 10 km per week for the past 12 months. Exclusion criteria were: (i) any current injuries; (ii) any current or past disease, condition or surgery which may affect running or walking patterns. The study was approved by the Australian Catholic University Human Research Ethics Committee (ID: Q2011/17). All participants provided written informed consent prior to participation.

A tri-axial accelerometer (Model: PCB356A32/NC, PCB Piezotronics, Buffalo, NY, USA) was attached to participants' right antero-medial distal tibia, such that the proximal-distal axis of the accelerometer aligned with the proximal-distal axis of the tibia, consistent with previous descriptions.[11,13] This was secured in place with several layers of tape (Omnifix, Hartmann, Rhodes, NSW, Australia) to prevent movement of the accelerometer relative to the tibia. Tibial acceleration data were sampled at 1500 Hz into Vicon Nexus (Vicon Motion Systems, Oxford, UK).

All participants attended two data collection sessions at the gait analysis laboratory (Fig. 1). The first session consisted of a "Baseline Run" of 5 min (no feedback), a 10 min rest, then the "Retraining Run", consisting of 10 min of running with feedback, then 10 min of running with feedback removed. Participants were randomised to receive either (i) clinician guided feedback or (ii) tibial accelerometry guided feedback, during the 10 min feedback period of the retraining run. The second session occurred 7 or 8 days after the first and consisted of a 5 min "Retention Run" without feedback.

For the duration of both sessions, participants wore standard running shorts and sandals (Santiam IV, Nike Inc., Beaverton, OR, USA). Following the attachment of the accelerometer participants completed a 7 min warm-up on a treadmill (Quasar, H/P Cosmos, Germany) directly followed by the 5 min baseline run (Session 1) or retention run (Session 2). Treadmill speed was set at 3 m s^{-1} for all running trials. Tibial accelerations were recorded for 5 strides in the last 10 s of each minute for all runs.

Participants randomised to the clinician guided feedback were instructed to listen to the verbal cues to "run softer" and "make your footfalls quieter" for the first 10 min of the retraining run, and then to try to continue to run in this way for the subsequent 10 min without verbal cues. The clinician provided these instructions repeatedly during the first minute of the run, and provided positive and/or negative reinforcement approximately every 30 s for the rest of the 10 min feedback period based on their assessment of how heavy the participants' footfalls were (Video S1, supplementary material). The nature of the feedback (i.e., positive or negative) was based upon the clinicians subjective judgement regarding how hard the participants footfalls were during the preceding 30 s. To ensure the clinician guided feedback replicated a situation where tibial accelerometry was not used, the clinician did not have access to the tibial accelerometry data until the completion of the study. The same musculoskeletal physiotherapist clinician/researcher provided feedback to all participants in this group and had 10 years of clinical experience.

Prior to the retraining run, participants randomised to the tibial accelerometry guided feedback group were oriented to a screen in front of the treadmill displaying a graph of their vertical tibial acceleration in real-time; the x-axis of the graph included an opaque shaded area representing >50% of their tibial acceleration in the last minute of the baseline run (Video S2, supplementary material). Participants were instructed that the trace on the graph provided a measure of how hard their footfalls were and asked to attempt to keep this trace out of the shaded area, or as close to this as possible. They were also told that this feedback would be provided for