REAL-TIME MUSIC-BASED BIOFEEDBACK TO REDUCE IMPACT LOADING DURING OVER-GROUND RUNNING

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INTRODUCTION

Running retraining through biofeedback on a measure of impact loading combined with simple instruction can decrease running related injuries [1]. Running retraining through real-time biofeedback on a direct measure of impact loading has been exclusively executed on treadmill [1,2]. For example, Peak Tibial Acceleration (PTA) was reduced by provision of simple auditory biofeedback within a single, treadmill-based retraining session [2]. Ecological validity could be improved by conducting retraining programs in an over-ground environment outside the laboratory and with a motivational bio-feedback approach.

In this 'proof of concept' study, retraining by means of real-time auditory biofeedback happened over-ground on an indoor running track in runners with elevated PTA. Impact loading was expected to be reduced within a single session.

METHODS

After screening 80 uninjured runners on PTA, 5 (3♂-2♀) high impact runners (height: 1.74 ± 0.02 m; weight: 71 ± 7 kg; age: 38 ± 11 years; weekly running volume: 25 ± 10 km; mean ± SD) were recruited in this ongoing study. These recreational, habitual rearfoot runners ran at least 15 km/week in non-minimalist footwear, were injury-free in the last 6 months and had no experience with gait retraining. They were instrumented with a wearable accelerometry system able to continuously detect PTA in real-time. Tibial skin was bilaterally pre-stretched before low-weight accelerometers (LSI 331, Sparkfun; 1000 Hz) were attached over the distal, anteromedial aspect of both tibia [3]. At an indoor track-and-field site (Flanders Sports Arena, 289 m/lap), participants were instructed to run at 3.2 ± 0.3 m/s. A warm-up of 4.5 min without bio-feedback was given while the average axial PTA was automatically determined for the leg bearing the highest tibial shocks. Lap times were used to give feedback on running speed. Real-time, music-based biofeedback was then provided for 20 min. in total (2*10 min. with ~ 5 min. intermittent rest). Music of a preferred genre was continuously synchronized to the runner's step frequency and was non-linearly distorted by superposition of pink noise according to the magnitude of elevated PTA [4]. To lower impact loading, runners were instructed to run with maximum music clarity and were not given any instructions on possible gait modifications. To account for any within-subject change in PTA during running, all PTAs were exported for further analysis using a custom MATLAB program. Wilcoxon signed-rank tests compared the mean running speed and mean PTA level between the no biofeedback and biofeedback (last 10 min. phase) conditions. The data were determined to be significant if $p < 0.05$. Mean ± SD are reported.

RESULTS AND DISCUSSION

Running speeds during the no biofeedback and biofeedback conditions were respectively 3.2 ± 0.1 and 3.1 ± 0.1 m/s ($p = 0.416$, $z = -0.813$), and thus speed had no confounding effect on PTA. Supporting our hypothesis, one retraining session with real-time biofeedback was enough to temporary decrease PTA in an over-ground setting (Table 1). The PTAs experienced by a representative runner during the over-ground running session are shown in figure 1. All subjects could decrease impact loading while listening to real-time biofeedback, and this without any instruction on gait modification but simply by means of impact sonification. The reduction of -2.7 g or -26 % in PTA was more than the achieved reduction in other single retraining sessions by auditory biofeedback on treadmill [2, 5].

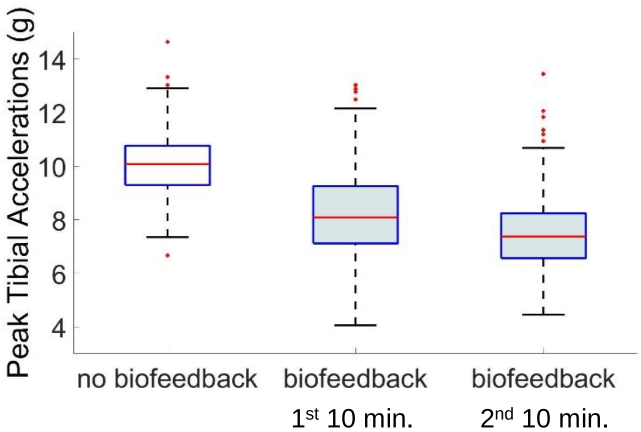

Figure 1: A Box-and-Whisker plot showing the distribution of peak tibial accelerations experienced by a representative participant.

The achieved reduction is arguably due to the more motivating form of the provided augmented feedback [6], consisting of music continuously synchronized to the runner's step frequency instead of simple beeps, and the cohort exhibiting high impacts along the lower leg's axial axis at baseline. Although other studies [2,5] demonstrated the effectiveness of auditory biofeedback by generating simple beeps for impact loading reduction on treadmill, this study is the first to show reduction in axial PTA in runners at-risk for the development of tibial stress injuries by applying more advanced and motivating real-time audio biofeedback and this in a non-lab environment. Besides the PTA acting along the axial axis, the impact shock severity along the other axes may also have altered and should be investigated in future and ongoing studies.

The feasibility of providing auditory information about clinically relevant biomechanical data per wearable biofeedback system eliminates the need of retraining exclusively in laboratory or clinic settings. This allows people to engage in gait retraining by means of impact sonification in their regular running environment (e.g. track-and-field, trail running) and is expected to increase the effectivity of and the adherence to a running retraining program.

CONCLUSIONS

High impact runners were able to temporarily decrease their PTAs during over-ground running by actively listening to and acting on music-based biofeedback without any instructions on gait modifications. Running retraining aiming at impact loading reduction by provision of augmented feedback on a direct measure of impact loading is possible in an ecologically valid environment.

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Table 1: Comparison of peak tibial acceleration (g) between the no biofeedback and the biofeedback (2nd 10 min.) conditions. Mean number of steps analyzed per subject: 383, no biofeedback; 872, biofeedback.

	No biofeedback	**Biofeedback**
Mean	10.4	7.7
Std. Deviation	1.5	0.8
Minimum	8.8	6.5
Maximum	12.6	8.5
p-value	0.043	
z-value	-2.023	