Beyond "How hard did it feel?"
What can we gain from the use of wearable sensors to monitor training loads in running?

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Summary

Training errors are often implicated in the development of running-related injuries (RRIs), yet little is known about "how much is too much" when it comes to progression of training loads. Biomechanical factors are also believed to moderate RRI risk since the magnitude and distribution of forces dependent on one's running form influences the incremental loads on a per step basis. We present preliminary findings from a study investigating RRI risk using simple consumer-grade wearable sensors to monitor training load and impact-related metrics. Our findings suggest that this method of monitoring training load may allow for greater prediction of RRI risk by capturing more than just volume and rating of perceived exertion (RPE).

The etiology of running-related injuries

It could be said that all overuse RRIs are a result of training errors, since to sustain an overuse injury one has to err by exceeding the limits in such a way that the repair process cannot keep pace with the stresses placed upon that structure. Injury occurs when the rate of application exceeds the rate of adaptation of the tissues. Training errors that have most often been identified as risk factors include excessive volume or intensity, or rapid changes in these variables. Outside of the running literature, a model described by Gabbett purports that athletes accustomed to high training loads (volume x intensity) have fewer injuries than athletes training at lower workloads [1]. Athletes who increased their acute workloads at too great a rate were more likely to sustain an injury. Taking this model and applying it to running, it makes sense that gradual increases and sustained running volume and intensity will have a protective effect against injury. Furthermore, there is evidence that under-training may also increase injury risk in a number of sports [1]. This may be one explanation for why novice runners are at an increased risk of running-related injury when compared to experienced runners. Regardless of training error, differences in individual thresholds exist between runners. It is therefore logical to assume that a combination of training and biomechanical factors contributes to injury risk.

The measurement of training loads

Training load—or more specifically change in training load—is undeniably a major cause of RRIs. However, an appropriate measure of training load is yet to be found. Various analytical approaches have been proposed to quantify training load [1-3], using primary exposures such as volume (external load) and intensity (internal load). However, these variables may be moderated by biomechanical factors affecting the distribution and magnitudes of these loads. The fusing of these effect modifying variables and the classic internal and external training load model has not yet been investigated. With the growing use of wearable technology, we have been presented with the opportunity for the continuous monitoring of these biomechanical factors on a per step basis. Using wearable devices in the community could give greater depth of knowledge about how runners' mechanics change in different environments, fatigue states, and over the course of a training program. To date, there have been no prospective studies that have investigated the risk of sustaining an RRI by measuring changes in workload (volume x intensity) and impact-related variables. In this presentation, we report preliminary findings from a 6-month prospective study investigating the role of volume, intensity, and impact-related metrics on RRI risk.

Methods

We recruited recreational runners aged 18-60 who had been running for at least 3 months and had not been injured within the last 6 months. Participants were excluded if they had a history of lower extremity joint surgery or any current pain with running. Written consent was obtained from all participants and ethics approval was granted from the institutional Clinical Research Ethics Board. Participants followed their regular training programs and trained in their regular running shoes. Each participant was fitted with two inertial measurement unit (IMU) sensors (RunScribe Plus, Scribe Labs, Moss Beach, CA), which were fastened to the laces of each running shoe. Three-dimensional accelerations and angular velocities, as well as total running time, were recorded for each run over a 6-month period. Participants also reported a Session Rating of Perceived Exertion score from 1-10, to quantify the intensity of the run. Injuries were monitored via a weekly online questionnaire and participants meeting the predetermined criteria were assessed by a physiotherapist for diagnosis and confirmation of RRI.

Conclusions

Borg's RPE scale has been shown to be a valid and reliable tool for monitoring exercise intensity (internal load) independent of many individual attributes and without the need for more invasive measurements of heart rate and blood lactate [4]. Given the amount of data we are now able to collect using wearable sensors, will this further contribute to our understanding of external training loads and, ultimately, injury risk? The results of this study suggest that consumer-grade wearable sensors may be a practical way to monitor training load in runners. Further analysis may allow for more accurate risk assessment and provide feedback via wearable devices on when to alter training to avoid encountering an RRI.

References

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