1.7 Running Injuries

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Are We Moving Forward in Research on Risk Factors for Running-Related Injuries?

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Current State of the Etiology of Running-Related Injuries

The high incidences of running-related injuries (RRI) have led many biomechanists, exercise scientists, clinicians, and statisticians to conduct research to uncover the many etiological factors responsible for RRI development. Since the mid to late 1970s (i.e., following the "running boom"), biomechanists and clinicians began their quest to identify RRI risk factors. In the 1980s and 1990s cross-sectional analyses with control groups reported running kinematics and anthropometric differences between uninjured and injured runners. Since then, although a plethora of cross-sectional analyses have been conducted, few large prospective studies have been available. More recently, a small number of prospective studies with relatively large sample sizes (i.e., 250+) have emerged to shed some light on possible biomechanical predictors of RRIs [1-3]. Interestingly, different biomechanical variables associated with prospectively injured runners were identified by these studies. Ultimately, we are still unable to confidently identify consistent RRI risk factors from the currently available prospective biomechanical research. A number of design and methodological limitations may contribute to inconsistent identification of risk factors.

Downfalls in Biomechanics Study Designs

One of the major design limitations of currently available prospective studies is the use of a single biomechanical testing session prior to an injury-monitoring period. A critical flaw in this approach is that it only captures biomechanical variables under non-fatigued, while running at few speeds or in one pair of shoes, and in perfectly controlled settings [4]. This approach therefore fails to capture the day-to-day nuances of running training that might be critical to truly understand injury development. Further, data analyses have been limited by commonly used statistical tests (e.g., logistical regressions) that cannot account for time-dependent running exposures or changes in dependent variable during the injury-monitoring period. More advanced statistical analyses including time-to-event analyses have been proposed to address current limitations in longitudinal data analyses for RRI detection and should help move the needle in the right direction for future prospective analyses [5]. There is a clear need for prospective experiments that include the tracking of day-to-day running exposures to better understand injury development.

Considering Daily Training Workloads

In the last 10 years we have seen an emergence of research focused on the influence of training-related factors on injury risks and development in various populations of runners. The majority of studies have focused on typical running-specific training quantifiers such as volume (e.g., minutes, miles or kilometres per week), intensity or pace (e.g., minutes per mile or kilometre, heart rate), and types of training sessions (e.g., slow/easy running, distance or time intervals, races). However, since the early 1990s, other approaches to quantify training "loads" have been proposed and used in practice. For example, training impulse (TRIMPs), session rate of perceived exertion (sRPE) among others have been used to better quantify training-intensity distributions in athletes [6]. Recently, the term "workload" has been popular within coaching and sports science literature and is described as the product of both external (e.g., volume, pace, external forces or segmental accelerations) and internal (e.g., sRPE, heart rate and heart rate variability) training loads to provide a more complete quantification of training exposure. However, limited prospective analyses on the importance of running workloads and RRIs are currently available. In this presentation, preliminary results of a 1-year online prospective survey study regarding the influence of week-to-week changes in training workloads on RRI will be presented along with the many challenges of conducting such large-scale online studies.

The Future of RRI Detection Approaches

Although running training workloads might provide more in-depth quantification of training stimuli, they do not address the individual running biomechanics of runners. Until recently, including running biomechanical variables in training monitoring has been difficult considering the impractical and time-consuming laboratory-based running biomechanical assessments. The emergence of wearable technology has made it much more practical to conduct prospective analyses that include daily running biomechanics data along with training-related details [7]. Although we are now able to obtain biomechanical data from wearable technology, there are still issues to overcome including data validity, management and analysis of large data sets, and practical implementation of findings for in-field interventions aimed to reduce RRI risks. Future experimental approaches will also need to consider strength, neuromuscular factors, tissue capacity, daily stressors, and clinical assessments to encompass all aspects of RRI risk factors.

In summary, we are certainly moving forward in our quest to better understand RRI etiology but we might need to abandon typical approaches and supplement our biomechanical data with day-to-day training factors to truly understand RRI risk factors and help reduce number and rates of RRIs. Within this symposium, Jonatan Jungmalm and Chris Napier will share their work that will contribute to bridging the gap between complex lab-based biomechanical assessments and models, clinical assessments, and daily training-related workloads to help identify RRI risk factors.

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Development of overuse injuries in running - A multidisciplinary approach

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Summary

This presentation will focus on the first results from a one year prospective cohort study on running-related injuries (RRI) conducted in Gothenburg, Sweden. The study combined biomechanical and epidemiological measures to try to shed light on the associations between possible risk factors (clinical, biomechanical and training-related), and RRI risk. One target was to identify sub-groups of runners having certain characteristics to describe possible differences compared with groups of runners. This is an important step towards understanding how much training load different types of runners can tolerate before sustaining an injury. Moreover, the importance of including a comprehensive baseline screening procedure will be discussed and problematized in the presentation.

Introduction

Running is associated with several health benefits such as increased level of fitness and decreased risk of cardiovascular and psychological disease compared with sedentary behaviour [1]. A major downside with running participation is the risk of sustaining an injury. From a public health perspective, it is important to keep as many runners as possible injury-free, so that the expected health benefits are not lost. Research about risk factors for RRI has been of interest in many studies in the past, but the only well-known risk factor associated with RRI seems to be *previous injury* [2]. A reason behind the difficulty to determine risk factors might be the multifactorial nature of RRI, with influences from e.g. clinical/anthropometrical and biomechanical characteristics. One step towards a more comprehensive approach is to explore potential risk factors and their association to RRI using absolute measures of association. A majority of the studies in the RRI domain have used regression analyses and relative measures of association [2, 3]. Of those studies using absolute measures of association, a majority have compared injured and non-injured runners, instead of comparing exposed vs. non-exposed [4]. Studies using an absolute measure of association when examining the association between biomechanical or clinical/anthropometrical characteristics and RRI are therefore needed. The purpose of the present explorative study was to investigate whether runners with certain biomechanical or clinical/anthropometrical characteristics sustain more RRI than runners having other biomechanical or clinical/anthropometrical characteristics.

Methods

224 injury-free, recreational runners were recruited from the Gothenburg Half Marathon and tested at baseline [5]. Baseline tests consisted of clinical/anthropometrical assessment and biomechanical measures of running movement and isometric strength. The runners were monitored during 52 weeks. The primary outcome measure was any running-related injury diagnosed by a medical practitioner. A 68% prediction limit was used for all movement- and strength-related exposure variables. The cut-off values were ±1 standard deviation (SD).

Results and discussion

Cumulative injury incidence proportion was reported to be 29% (95%CI = 24%; 35%). Runners with a late timing of maximal pronation or weak abductors in relation to adductors sustained more injuries compared with the corresponding reference group. Although not significant, runners with painful trigger points seem to sustain more RRI compared with runners not showing painful trigger points.

Conclusions

The results from the present study add new information regarding whether runners with certain characteristics sustain more RRI than runners having other characteristics. More injuries are likely to occur in runners with late timing of maximal pronation or weak abductors in relation to adductors. From the results from this study, it can be hypothesized that runners with trigger points are sustaining more injuries compared with runners not having trigger points.

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Combining biomechanics and epidemiology in running injury research

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Summary

Most running injury studies have used either purely biomechanical [1,2] or purely epidemiological [3,4] methods. Results from biomechanical studies comprise stepwise kinematic and/or kinetic variables, e.g. joint angles and/or moments, while results from epidemiological studies comprise training variables (e.g. number and length of weekly sessions), anthropometric variables (e.g. body mass), as well as number and type of injuries. The problems with the purely biomechanical studies are that despite knowledge of stepwise load, we still cannot say how this accumulates over time (running session, weeks, …) or when accumulated load exceeds the injury threshold. The problem with the purely epidemiological studies is that without biomechanical variables, it is impossible to establish the causal connection between (accumulated) load and injuries. By combining biomechanical and epidemiological methods, we aim to overcome these problems. Please note that this paper describes a work in progress.

Introduction

Running is the most popular recreational sport activity with millions of runners worldwide. However, with running comes the risk of running injuries, preventing runners from running for shorter or longer periods, witch concomitantly compromises the health and life quality benefits associated with running. It is therefore important to understand the development of running injuries, and ultimately be able to advise the individual runner on how to keep running without sustaining injuries.

Running injury studies are methodologically either biomechanical or epidemiological.

Biomechanical studies routinely utilise conventional, laboratory based motion analysis methods, involving a limited number of subjects, to quantify kinematic variables (e.g. step length, joint ankles, strike pattern) and/or kinetic variables (e.g. joint moments). Sometimes more elaborate modelling methods are involved, allowing estimation of forces applied to specific, anatomical structures. The major problems with the biomechanical studies are that even with precise knowledge of stepwise, structure specific load, we would still not know how stepwise load accumulates over time (running session, weeks, …) or when accumulated load exceeds the injury threshold, which in itself might be modified by running.

Epidemiological studies routinely utilise questionnaires, involving hundreds or thousands of subjects, to quantify training variables (e.g. number and length of weekly sessions), anthropometric variables (e.g. body mass), as well as number and type of injuries. The major problem with epidemiological studies is that without the above mentioned biomechanical variables, it is impossible to establish the causal connection between structure specific, accumulated load and injuries.

The aim of our research is to combine biomechanical and epidemiological methods to overcome these problems.

Methods

Over the last decade, conventional epidemiological studies have been published by our group [e.g. 3,4] and others [e.g. 5,6]. Recently, however, technological advances in smartwatches and body and/or shoe worn censors are beginning to allow large scale studies with field based measurements of data of a more biomechanical nature (e.g. stride length and frequency, strike pattern, vertical displacement of the body centre of mass).

Our first step in combining biomechanical and epidemiological data is a cross-sectional laboratory study on a limited number of recreational runners, running with different speeds and styles (e.g. step length, strike pattern). We intend to measure conventional, biomechanical data (motion capture, force plates) while simultaneously measuring "field data" (i.e. biomechanical data that can also be measured in the field using smartwatches and body/shoe worn censors). Having access to both detailed laboratory data and simultaneous field data, we hope to be able to establish relations between field and laboratory data, allowing us to predict or estimate laboratory data (e.g. joint kinematics, magnitude and direction of the ground reaction force) from field data. This will enable us to perform conventional, biomechanical calculations of joint moments and possibly also modelling based estimations of structure specific loads entirely from field data.

Our second step is a prospective study on several thousand runners performing their usual running schedule. We intend to measure field data and injury data (type and time of occurrence). Field data will be uploaded automatically to a central database from the runners smartwatches via an already developed and tested app [4], while injury status will be communicated via email.

Results and Discussion

As these studies are works in progress, we cannot present results at this time. We do, however, believe that our approach has the potential to reveal the underlying mechanisms for injury development, i.e. how running style is linked to stepwise load, and how running regime links stepwise load to accumulated load and further to possible injury.

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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.

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