Musculoskeletal injury rates in multiday marathon runners performing ten consecutive marathons on a repeat course

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Musculoskeletal injuries in daily marathon running

ABSTRACT

Objective: To describe musculoskeletal injury rates in recreational runners completing ten marathons over ten consecutive days to help event organisers plan future injury preventative advice and strategies.

Methods: An observational study involving 27 recreational runners (age 45.1±7.47 yrs, mass 74.5±12.39 kg, years running 11.6±9.42 yrs, average weekly mileage 41.9±12.72 miles). Main outcome measures included total and percentage of musculoskeletal injuries, timing of injury occurrence during 10-day event, and daily individual marathon times.

Results: Twenty-six runners sustained 108 injuries, averaging 4 injuries per runner (90.13 per 1000hr). 89% of injuries involved the lower extremity; 24.1% foot, 18.5% hip/buttock, 16.7% ankle and 16.7% lower leg. Common injuries were blisters (15.7%), Achilles tendinitis (11.1%), medial tibial stress syndrome (MTSS) (10.2%), iliotibial band syndrome (ITBS) (9.3%) and low back pain (LBP) (9.3%). 64.3% of injuries were sustained to the left limb. Chi-squared analysis revealed more injuries in days 1–3 than days 4–6 (p=0.013) and days 7–10 (p=0.001). Repeated measures ANOVA comparing Days 1-3, 4-6 and 7-10 showed a significant main effect (p=0.039). Post hoc analysis revealed Days 1-3 were significantly quicker time than days 7-10 (p=0.037, difference of 0.276 hrs).

Conclusion: Blisters, Achilles tendinitis, MTSS and ITBS are the most common lower extremity injurie in multiday marathons runners performing a repeat course over 10 consecutive days. Runners entering these events should perform appropriate injury prevention programmes. Runners should also be more reserved at the beginning of multiday events to avoid high initial injury risk. However, further investigation of injury rates and risk factors using larger sample sizes is required.

INTRODUCTION

Ultra-endurance events have grown rapidly in popularity in the past few decades[1,2], with 313 multiday and over 3000 ultra-endurance events planned for the Worldwide 2017-18 race calendar. Events vary in nature, ranging from point-to-point continuous running (100-150 miles) in a specified time, or more recently multiday point-to-point ultra-marathon races. Multiday competitions, such as RacingThePlanet© and the Trans Swiss Run© typically last 6-7 days in duration and cover 150 miles in total. Previous studies have investigated multiday ultra-endurance events using various sports, including running, cycling and swimming[3-5], with the focus on effects to the immune function, skeletal muscle damage and nutritional elements linked to recovery[6]. However, despite the growth in interest of multiday ultra-endurance events, little data exist regarding injury rates to athletes. A greater awareness of injury epidemiology is the foundation for prevention strategies[7].

Few studies have investigated injury rates during multiday ultramarathon road race events. An early study by Hutson[8] observed 24 runners during a six-day track race, covering a total distance of 936km. It was reported that >60% of runners experienced an injury, the majority of which were noted as 'mild' in nature. The authors also observed the preponderance of injuries to the lower extremity, primarily the knee and ankle, although exact incidence rates were not reported. Fallon et al.[9] studied 32 runners during a 1005km multiday road race. The runners sustained 64 musculoskeletal injuries, with 72% of all runners obtaining a minimum of one injury during the event. The authors reported the knee (31.3%) and ankle (28.1%) as the most commonly injured body regions. Another study by Bishop and Fallon[10] followed 17 runners completing a six-day track race. The authors noted a musculoskeletal injury rate of 65%, with injuries again most frequently sustained to the ankle (36%) and knee (22%). However, it is difficult to compare injury incidence rates between studies when injuries per 1000 h of running is not reported[11]. In a systematic review and meta-analysis into incidence of running related injuries per 1000 hours of running in different types of runners, only one study to date has recorded this[12]. Krabak et al.[13] recorded an incidence rate of 65 injuries/illnesses per 1000 hours running, and 3.86 injuries per runner. However, this five day staged 240km event over desert/wilderness terrain was performed in several locations throughout the world and with a wide variance in location temperature (10°C-48°C) and altitude (-30-+4300m). Therefore, it is unknown whether injuries/illnesses were related to the unique and varying conditions and running routes, and/or the accumulation of multiday endurance running.

Previous research has either investigated races on a repeated athletics grass track-based course[10], which lacks external validity, or road[9] and wilderness terrain[13] over a set point-to-point long distance, which lacks between day repeatability and reliability of terrain, direction and surface camber. To our knowledge, no study has evaluated injuries in multiday endurance runners performing a repeat course, over consecutive days. Therefore, the aim of the present study was to record musculoskeletal injury rates; areas and type, in recreational runners completing 10 marathons over 10 consecutive days using the same racing route. Daily individual race times would also be recorded to observe the relationship between injuries and race times over the 10-day event. The information gained would help inform race organisers and future event participants of injury prevention strategies.

METHODS

This was an observational prospective cohort study completed during the 2015 and 2016 'Brathay 10 in 10'. The 'Brathay 10 in 10' is a unique endurance event. It consists of running ten marathons over ten consecutive days (total: 422km), on the same course, running around Lake Windermere in the Lake District, England. All runners completed a 42.2km marathon on each of the ten days. The course remained the same, performed anticlockwise on a road tarmac surface, with the race start time set at 10:30am each day. Participants were recruited by the event organisers, through the Brathay Hall Trust, Ambleside, England. All participants were experienced endurance runners; training and competing endurance/ultra-endurance events on a regular basis. The authors met with all participants four months prior to the events in 2015 and 2016, whereby they introduced the runners to the study design and rationale, and asked them to participate. All participants enrolled in the study gave their voluntary, written informed consent for their medical and race information to be used for research purposes. The study protocol was ethically approved by the University of Cumbria Ethical Review Board.

Twenty-seven recreational runners entered the study (17 male, 10 female, age 45.1±7.47 yrs, mass 74.5±12.39 kg, years running 11.6±9.42 yrs, average weekly mileage 67.4±20.5 miles). On commencing the event, all runners were approved as 'fit to compete', without significant injury, by an experienced sports therapist. The medical staff consisted of two practitioners: a Sports Therapist and Sport Rehabilitator. Both were experienced in the medical care of ultra-marathoners and management of running injuries. The medical staff collected data on musculoskeletal injuries from the runners a minimum of three times every 24-hour race-day period. Injuries were defined as 'a specific musculoskeletal abnormality that the runner perceived to affect his/her performance' (Bishop and Fallon, 1999) and were assessed and confirmed by both musculoskeletal therapists. All injuries were recorded on a standardized injury audit form noting the diagnosis, site of the injury and timing of onset during the event. Any participant who was unable to start a stage of the event was considered removed from the competition. Finally, individual race times were recorded daily by an independent timing system (SPORT_ident).

During the daily marathons, participants could carry any food/drink they required, however, they had pre-prepared feed stations at two mile intervals, with food/drink supplies. All participants could choose their type and amount of food/drink daily. Race conditions varied each day, although maximum and minimum temperatures were 16˚C and 6˚C, respectively. Race altitude was 183.7ft at the start, with a maximum elevation of 456.0ft and total ascent over the marathon course of 1492.8ft.

Statistical Analysis

The total number of injuries and injuries by location were calculated as frequencies, percentages and per 1000hrs of running. Average race times were calculated as means and standard deviations. All statistical analyses were completed in SPSS (Version 24, IBM Corporation, New York, USA). Pearson's Chi-Squared analysis was used to compare the frequency of injuries from Days 1-3, Day 4-6 and Days

7-10, with an alpha level set at p ≤0.05. The Kolmogorov–Smirnov test was used to examine normality of race time data, which was confirmed (p =0.200). The differences in race times between Days 1-3, Days 4-6 and Days 7-10 were analysed using a one-way repeated measures ANOVA again with significance accepted at p ≤0.05. The assumption of sphericity was violated (Mauchly's test p = 0.012) therefore the Greenhouse-Geisser correction was applied to the main effects analysis. Post-hoc pairwise comparisons were completed using a Bonferroni analysis with alpha level set at p ≤0.05.

RESULTS

26 runners completed the event and all 10 consecutive marathons. One runner withdrew due to serious injury; diagnosed as a Grade II medial collateral knee ligament injury. The injury occurred during day 5 of the event, whereby the runner withdrew at 8km into the marathon. Previous injury data concerning the runner was removed from statistical analysis.

Injuries

Twenty-five of the runners (95.16%) sustained a total of 108 injuries, averaging 4 injuries per runner (90.13 per 1000hr). Only one runner sustained no injuries, whilst the highest number of injuries recorded per runner was 10. A total of 64.3% of injuries were sustained to the left limb.
89% of injuries involved the lower extremity; 24.1% foot, 18.5% hip/buttock, 16.7% ankle and 16.7% lower leg. The remaining 11% of injuries were spinal/trunk. Common injuries were blisters (15.7%; 14.18 per 1000hr), Achilles tendinitis (11.1%; 10.01 per 1000hr), medial tibial stress syndrome (MTSS) (10.2%; 9.18 per 1000hr), iliotibial band syndrome (ITBS) (9.3%; 8.35 per 1000hr) and low back pain (LBP) (9.3%; 8.35 per 1000hr).

Injury Incidence and Race Time

Chi-squared analysis revealed more injuries in days 1–3 (54) than days 4–6 (31) (p=0.013) and days 7–10 (23) (p=0.001). Repeated measures ANOVA comparing Days 1-3, 4-6 and 7-10 showed a significant main effect (p=0.039). Post hoc analysis revealed Days 1-3 were significantly quicker time than days 7-10 (p=0.037, difference of 0.276 hrs) (Figure 1).

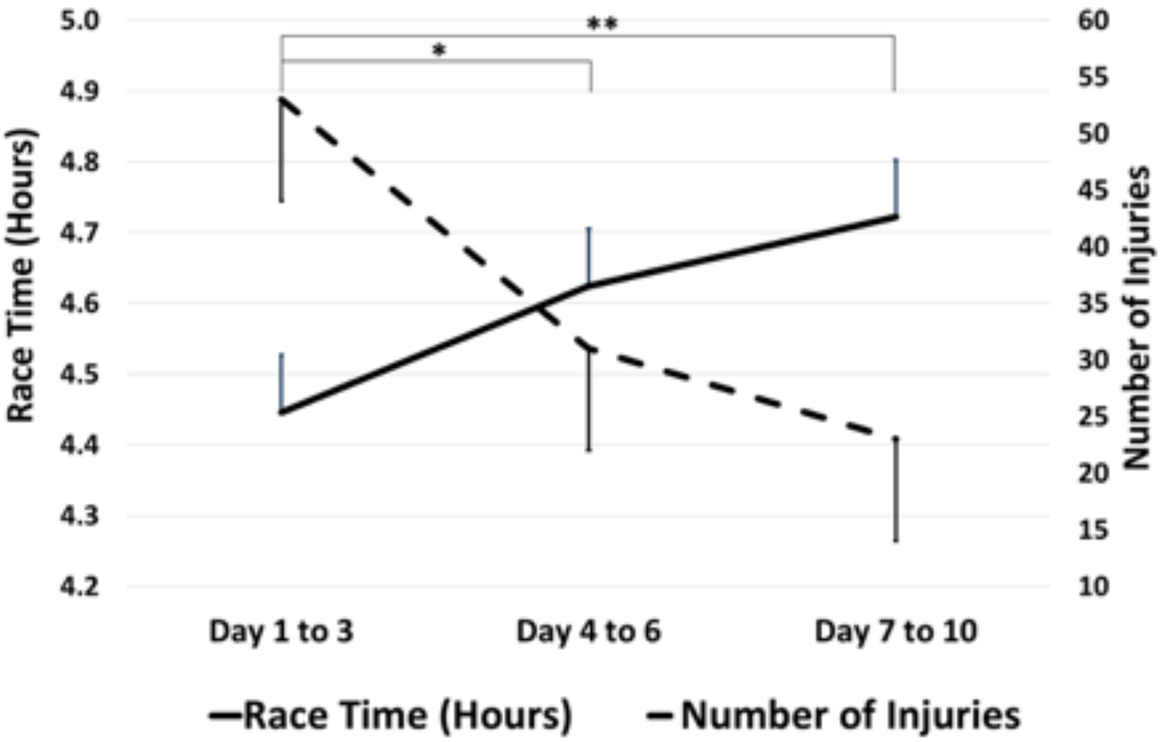

Figure 1. Race Times (mean+SE) and Number of Injuries (sum-SE). *Sig. difference in injuries between days 1-3 and 4-6. ** Sig. difference in injuries and time between days 1-3 and 7-10.

DISCUSSION

Despite the increased popularity in multiday ultra-endurance events, there is little data regarding injury epidemiology. To our knowledge, this was the first study to report on musculoskeletal injury rates in ultra-endurance runners performing consecutive marathons on a repeat road-based course. In our study, 95.16% of runners sustained injuries, which is higher than reported in previous multiday endurance running research (56.5-84.8%[10,13-15]). This averaged at 4 injuries per runner, compared to 0.71-2.7 injuries per runner in previous studies[9,13]. The overall injury rate was 90.13 per 1000hr, which again is higher than that observed by Krabak et al.[13] in a five day off-road ultra-endurance study (65 per 1000hr). However, no other studies concerning ultra-endurance running events are available for comparison since they did not report the injury rate per 1000 hours, or total hours for all runners for it to be calculated retrospectively. This limitation has previously been highlighted by Jakobsen et al.[11] as it would help provide a more comparable measure of association. However, when considering individual marathon events, the rate observed in the current study is also, unsurprisingly, significantly higher (6.8-59 per 1000 hours[16]). This study involved the greatest number of consecutive marathons (10) in comparison to previous multiday endurance running event studies (4-8.5 days), or single marathon events, which may explain the high incidence rate observed. Furthermore, musculoskeletal injury rates may be lower in previous ultra-endurance running studies due to the off-road nature (trail or grass) as opposed to road running which is associated with increased chance for cumulative trauma[13].

Regarding musculoskeletal injuries sustained, blisters were the most commonly reported (15.7%; 14.18 per 1000hr). This is lower than reported by Scheer and Murray[15] and Krabak et al.[13] (26.1 and 55.58%, respectively), although which is in line with single marathon running events (0.2-39[17]). Risk factors associated with blisters include heat, moisture, increased running volume and ill-fitting footwear[17]. Runners in the current study were prone to changing footwear during the event. The increased variety, potentially including ill-fitting shoes, may have contributed to the high incidence rate observed, although this is only conjecture and warrants further investigation.

Achilles tendinitis was recorded as the second most common injury with an incidence rate of 11.1% (10.01 per 1000hr). This is consistent with previous research by Hoffman and Fogard[18] (11.5%), and other ultra-marathon studies where prevalence rates have been reported 2-18.5%[16]. Excessive loading during physical activity is considered to be the main stimulus for the development of tendinopathies[19]. The high, repetitive loading generated in the gastrocnemius and soleus during running may predispose runners to the development of Achilles tendinitis[20]. However, despite ten consecutive marathons completed in the current investigation, the incidence rate of Achilles tendinitis wasn't as high as reported by other research from Lopes et al.[16] involving lower volume events. This may be explained by the different types of running surface in the events studied. It has been reported that softer surfaces, such as trail or sand, demand higher propulsive forces on push-off[21], compared to road as was the running surface in the current investigation. Consequently, runners may adopt a greater forefoot running technique which decreases landing time and increases running velocity, but whilst creating a higher load on the Achilles tendon, leading to more degeneration[21]. However, there are little high quality prospective cohort studies which compare Achilles tendon loading on different terrains to confirm these findings.

In a systematic review by Lopes et al.[16], Medial tibial stress syndrome (MTSS) was reported to account for 7.8-11.1% of total injuries in ultra-marathon events which is supported by the current observed incidence rate of 10.2% (9.18 per 1000hr). MTSS refers to exercise-related pain at the posteromedial border of the mid-distal tibia[22]. The high frequency rate of MTSS has been suggested to be related to insufficient capacity of bone remodelling constituted by repetitive and persistent stress on the tibia by muscular contraction and high ground reaction forces during running[23]. This may be exacerbated for the runners during the study due to inadequate healing time when running over 10 consecutive days. Other factors such as predisposing biomechanical issues, hyperpronation, greater knee valgus or different types of running have also been associated with development of MTSS[24]. However, cause-effect relationships are yet to be determined[16].

Iliotibial band syndrome (ITBS) has been reported as the most common cause of lateral knee pain in runners, with an incidence rate of up to 12%[25]. A similar incidence rate was found in the present study of 9.3% (8.35 per 1000hr), although which is higher than that reported by Fallon[14] (4.7%) in ultra-marathon runners. The ITB is a lateral stabiliser of the knee joint[26]. Straus et al.[27] proposed an impingement zone at 30° knee flexion, and that running uphill and downhill, which is common in ultra-marathons, may lead to higher fractional time in this zone. The marathon course used in the current study involved a total ascent of 1492.8ft, which may therefore explain the higher reported incidence rate of ITBS.

Whilst lower limb injuries constituted 89% of total injuries, the remaining 11% of injuries were to the spine/trunk. Specifically, low back pain (LBP) accounted for 9.3% (8.35 per 1000hr) of all injuries. This is greater than observed by Fallon[14] (3.1%). Higher loading may be associated with running on a harder surface (tarmac road in the current study), whereby impact on foot-strike can be up to three times total body weight[29]. This may help explain the higher incidence of LBP recorded in the present study. However, further epidemiological, as well as biomechanical studies are required to substantiate these claims.

When excluding spinal injuries, 64.3% of injuries were sustained to the left limb. The finding of left predominance to injury is in agreement with previous studies during both ultra-marathons events[14] and long-term endurance running training[28]. However, in a study by Fallon and Bishop[10], there was an even distribution of injuries between left and right limb. Both this, and the previous study by Fallon[14] were performed as ultra-endurance events over six days on a track course. However, in the latter study by Fallen and Bishop[10] the runners were instructed to change direction every 2-hours, as opposed to uni-directional running in the previous study by Fallon[14]. It has been hypothesized that road camber can lead to unequal load distribution on the legs[28]. This repetitive biomechanical alteration in gait pattern may have resulted in the increased incidence of injuries to the left leg. However, few studies discuss road camber in relation to injury incidence as an aetiological factor, and therefore further research is required to explore this area.

Krabak et al.[13] observed a cumulative effect for musculoskeletal injuries later in multiday endurance running. This was expected by the authors, who suggested that greater incidence of injuries would develop when running greater distances on sequential days and without standard rest/recovery time. Whilst this does indeed seem logical, current findings contradict this theory. Results from the investigation observed significantly more injuries in days 1–3 than days 4–6 and 7–10. This finding may be related to race times over the 10 days. There was a general pattern of increased race times over the 10-day event, with race times in days 1-3 significantly quicker than days 7-10. It could be postulated that, following a likely period of tapering prior to the start of the event, runners entered feeling rested and therefore began with a higher pacing strategy. However, increased pace has been associated with overuse injury in runners, including Achilles tendinitis as was prevalent in the current study, even if running volume remains the same[30]. This may be related to quicker muscle tension alterations which lead to increased predisposition to microtears as pace increases[31]. Consequently, and due to reduced function and/or increased pain associated with injury, runners may then have been forced to reduce their pace, thus reducing further injury susceptibility. However, it could also be considered that by the latter stages of the event runners had learnt techniques to treat their own injuries and therefore not presented or detailed the conditions to medical staff, thus lowering the end-stage reported injury incidence rates. This was observed by Krabak et al.[13] whereby runners self-treated for blisters towards the end of multiday endurance events.

Limitations

This study describes musculoskeletal injury rates during 10-day consecutive marathon running on the same course and is limited by its small sample size. Collecting and reviewing data over forthcoming years and events would provide a more accurate assessment of injury epidemiology in this demographic. Furthermore, the methods of data collection used did not allow for identification of injury risk factors such as demographic, anthropometric, health history and training history, which may be an area of future research exploration.

CONCLUSIONS

In summary, this study observed common musculoskeletal injuries in multiday ultra-endurance runners completing 10 marathons over 10 consecutive days, on the same road-based circular course. The vast proportion of injuries were in the lower extremity; the most common being blisters, achilles tendinitis, MTSS and ITBS. Athletes entering these events should engage in appropriate injury prevention programmes to target these injuries. The majority of injuries were sustained to the left limb; multiday marathon event organisers should consider alternating route direction to reduce injury risk, potentially the result of prolonged, altered gait biomechanics. There was an inverse relationship between injuries and race times, with most injuries sustained in days 1-3, and during faster individual race time days. Future runners should consider a slower, more gradual start to multi-day endurance events. However, further investigation of injury rates and both etiological and biomechanical risk factors using larger sample sizes is required to further inform this area of study.

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