

Pain during a marathon run: Prevalence and correlates in a cross-sectional study of 1251 runners

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Research article

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Abstract

Background Science-based information about pain during a marathon run is scant. Based on related research it was hypothesized that: (i) most marathon runners would report moderate intensity pain, (ii) pain during the marathon would be associated with pain experienced while training as well as overall perceived exercise intensity, and (iii) females would experience pain earlier during the marathon and rate the pain intensity as higher after adjusting for expected sex-related differences in effort.

Methods 1,251 runners, 550 females, ran in 252 different marathons and completed an online survey. Mile at which pain first occurred indicated pain threshold. Pain intensity was measured with a widely used 0–10 numerical graphical scale. Pearson and partial correlations examined the strength of associations. Sex-related differences in pain were tested using independent t-tests and, for the pain location data, z-scores for tests of two proportions. Effort ratings were added as a covariate in an ANCOVA to test if effort accounted for possible sex-related differences in pain.

Results Most runners (99.8%) reported pain during a marathon, and most frequently in the thigh (17.1%), hamstring (10%) and calf (9.3%) body locations. The mean pain threshold occurred at 15.7 ± 6.1 miles; the mean overall pain intensity was 5.26 ± 2.45 . No sex-related pain differences were found. Overall pain intensity during a marathon was significantly associated with: pain intensity of training runs ($r = .39$), percentage of training days with run-induced pain ($r = .23$), highest intensity pain ever experienced ($r = .23$), number of prior marathons ($r = -.18$) and intensity of effort ($r = .11$) (all $P < 0.001$).

Conclusions Most runners experience moderate to very strong intensity pain during a marathon; the pain is independent of biological sex, and the pain is associated with marathon race experience, pain during training, race effort and the highest intensity of pain ever experienced.

Background

Pain during marathon running has received little attention from researchers. Closely related research has tested potential treatments for muscle pain experienced post-marathon (1), documented pain sensitivity to cold or pressure following longer, ultramarathon runs (2), or been focused on specific types of pain associated with marathon running such as breast pain (3). Whether there are sex-related differences in leg pain during marathon running has rarely been investigated. Compared to groups of males, female samples are characterized by a lower pain threshold and report higher pain ratings when given standardized noxious stimuli in laboratory settings (4).

The aims of this cross-sectional study were: (i) to describe pain experiences during a 26.2 mile marathon (i.e., pain threshold, primary body location of the pain and its pain intensity), (ii) to quantify selected correlates of the average pain intensity experienced at the primary location of pain during a marathon, and (iii) to consider possible sex-related differences. It was hypothesized that most participants would report pain during the marathon ($> 50\%$), and on average the pain would be of moderate intensity. It was also hypothesized that the intensity of effort put into the run would be significantly correlated with the

average pain intensity during the marathon as would the presence of pain experienced while training for the marathon. Lastly, it was hypothesized that females would experience pain earlier during the marathon and would rate the intensity as higher after adjusting for expected sex-related differences in effort (5).

Methods

Design

A cross-sectional design was used to answer the research questions. All methods were approved by the Institutional Review Board prior to collecting data and written informed consent was obtained from all participants. Adult participants were recruited using announcements that asked marathon runners to complete a survey of ~ 10 minutes.

Participant recruitment

To obtain information on a broad sample of marathon runners rather than recruit runners from a single, local marathon race a cross-sectional online survey was used. Announcements were available on websites of interest to marathon runners such as race websites, running shoe and apparel websites, and online discussion groups. The announcements had a link to the survey questions, which were administered electronically via Survey Monkey (www.surveymonkey.com).

Survey

The survey, available from the author, was developed for the study and consisted of 41 questions. A subset of questions was focused on demographics and history, including biological sex, age, body weight, the number of prior marathons run, and the intensity of the most intense pain ever experienced.

A subset of questions targeted the most recent marathon run. Participants reported on the number of weeks since the most recent marathon had been completed, the name of the marathon and the date it was run. Other questions included the location and intensity of pain at the starting line before the run began and the race mile at which the participant began to feel pain (0.5 to 26.2 mile mark); this served as an index of pain threshold. The primary location of pain during the most recent marathon was queried, as was the average intensity of pain during the marathon at the primary pain location. Pain location was selected from a list of 27 specified body sites. A 28th option allowed participants to choose, but not specify, "some other site". The participants reported their finishing time and the overall perceived intensity of effort put into the most recent marathon run was reported using Borg's 6–20 scale (6).

A subset of questions asked about responses to training which preceded the most recent 26.2 mile marathon run and were thought to be of potential relevance to pain experienced during the marathon. These included an estimate of the percentage of training days that running-induced pain occurred and the average intensity of pain at the primary pain location during training.

All the pain intensity questions used a 0–10 numerical category pain intensity scale. This scale yields responses similar to a ratio scale and results from several hundred experiments support its validity as a measure of pain intensity (7).

Statistical analysis

Analyses were conducted on a total of 1,251 respondents; these were the individuals who provided answers to the majority of questions and had an absence of inaccuracies on questions that could be verified (e.g., responses outside the possible range on a variable, such as age > 120). A total of 1.4% of the possible responses were missing among the 1,251 respondents; the pain threshold question accounted for 56% of these missing data points. Pairwise deletion was used to address missing data. Data were imported into Statistical Package for Social Sciences (version 24) for analysis. Analysis included descriptive statistics, such as means, standard deviations, standard errors and 95% confidence intervals. The magnitude of sex-related differences was described using the Cohen's *d* effect size metric and the statistical significance was tested using independent *t*-tests and, for the pain location data, *z*-scores for tests of two proportions. Pearson and partial correlations examined the strength of associations. Effort ratings were added as a covariate in an analysis of covariance to test if effort accounted for possible sex-related differences in pain. Significance was set to $P < .001$, rather than $.05$, to minimize potential bias resulting from conducting multiple statistical tests.

Results

The participants participated in 252 different marathons held in Australia, North America (Canada and the United States) and Europe (Denmark, England, France, Iceland, Ireland, Italy, Netherlands, Poland, Russia). Ninety-five percent of the marathons were run in the United States; 45% of the participants ran either the Chicago (8.1%), Twin Cities (7.7%), Georgia (7.4%), Boston (7.0%), New York (4.6%), Marine Corps (3.7%), Grandma's (2.3%), Disney World (2.2%) or San Diego (2.0%) marathons. Respondents focused on their most recent marathon, which had been completed within the prior year for 75.7% of the participants. The median and mode number of weeks since participating in the marathon was 21 and 1, respectively. There was not a significant difference between the female and male sample for the number of weeks since the last marathon had been completed.

Descriptive statistics for the female and male samples are provided in Table 1. The sample consisted of 44% females and 56% males. As expected, there was a large mean difference in body weight between the sexes and, on average, the male sample ran the marathon in less time than the female sample (mean of 31 minutes). Two other sex-related differences were significant: the lower mean perceived exertion ratings of 0.61 raw score units (Cohen's *d* = 0.28) and higher average pain during training of 0.41 raw score units (Cohen's *d* = 0.28) for the female sample.

Table 1
 Characteristics of the female and male samples of marathon runners surveyed.

Variable	Sex	N	Mean	SD	Cohen's d	Sex difference p-value
Age – yrs	Female	552	36.03	10.15	.40	< 0.001
	Male	696	40.32	11.22		
Body weight - kg	Female	535	59.65	7.54	1.73	< 0.001
	Male	688	75.08	10.10		
Pain at primary pain location – 0–10	Female	553	5.43	2.45	.13	0.026
	Male	698	5.12	2.43		
Highest intensity pain ever experienced – 0–10	Female	551	9.11	2.60	.05	0.353
	Male	695	9.24	2.66		
Prior marathons run	Female	553	6.84	12.46	.15	0.009
	Male	698	8.78	13.47		
% of training days with running-induced pain	Female	553	24.44	23.20	.15	0.008
	Male	698	21.02	21.97		
Pain intensity at primary location in training – 0–10	Female	553	4.97	1.89	.21	< 0.001
	Male	698	4.56	1.95		
Perceived exertion – 6–20	Female	553	14.38	2.18	.28	< 0.001
	Male	698	14.99	2.24		
42K run time - minutes	Female	523	261.95	49.99	.63	< 0.001
	Male	665	230.58	49.67		
Start line pain intensity – 0–10	Female	553	1.40	1.15	.07	0.239
	Male	698	1.32	1.07		

There was no significant sex-related difference in the location or intensity of pain at the starting line. For the combined sample of females and males, 85% percent were pain-free at the starting line. There were four body locations that at least 1% of the sample reported pain at the starting line: heel (1.1%), achilles (1%), hamstrings (1%) and iliotibial band (1%).

During the marathon, the primary site that pain was experienced most frequently was the thigh (17.0%), hamstring (10.1%) and calf (9.3%) muscle groups followed by the front (5.2%) and lateral (5.0%) portions

of the knee. The next most frequent primary pain sites were the iliotibial band (4.6%), ball of the foot (4.1%), hip (3.3%), hip flexor (2.9%), low back (2.7%), toe (2.4%), arch of the foot (2.3%), medial part of the knee (2.2%) and heel of the foot (2.1%) sites. Between one and two percent of the sample reported pain at seven other sites: ankle (1.8%), achilles (1.8%), abdominals (1.6%), buttocks (1.6%), shin (1.5%), top of the foot (1.4%) and groin (1.3%). The percentage of the sample reporting pain at other sites was less than 1%: chest (0.7%), shoulders (0.7%), upper back (0.3%), neck (0.3%), arms, hands and fingers (0.2%) and head (0.1%) while 2.8% reported that some other site was the primary pain location. There was no primary pain location for 10.2% of the sample.

The percentage of female and male samples reporting pain did not differ significantly at any of the 27 body locations listed above. The largest differences were that a greater percentage of men versus women reported pain at the thigh (19.5% vs. 13.8%) and the calf (11.4% vs. 6.4%) locations. A greater percentage of women versus men reported pain at the hip (4.9% vs. 2.0%), lateral knee (6.5% vs. 3.7%), iliotibial band (5.8% vs. 3.6%) and front of the knee (6.4% vs. 4.3%) locations.

The mean \pm SD mile at which the females and males began to feel pain during the marathon were 15.3 ± 6.1 and 16.0 ± 6.1 , respectively. The associated 95% confidence intervals for the female (14.7 to 15.8) and male (15.5 to 16.4) samples overlapped and there was no significant sex difference in this index of pain threshold ($t = 1.877$, $df = 1,109$, $p = 0.061$; $d = .11$). For the entire sample who reported ($n = 1,111$), pain threshold was normally distributed and on average occurred at 15.7 ± 6.1 miles into the run (95% CI: 15.3 to 16.1); these data are illustrated in Fig. 1.

There was not a statistically significant sex-related difference in the average pain intensity at the primary location. Among the entire sample, 25% rated the pain of marathon running as a “very strong” or higher pain intensity while only 2 runners reported no pain during the marathon. For the entire sample, the mean and mode responses were ratings of 5, indicating that the average pain of marathon running typically represented a “strong” intensity. The mean and SD were 5.26 and 2.45 while the 95% confidence interval ranged from 5.12 to 5.40. For the entire sample, the pain during the marathon was higher than that typically experienced during training (4.7 ± 1.9) and lower than the highest intensity pain ever experienced (9.2 ± 2.6). The average pain intensity was non-significantly higher for the female (5.43 ± 2.45) versus the male (5.12 ± 2.43) sample and the difference did not become significant after accounting for sex-related differences in effort in an analysis of covariance.

Pain during the marathon was correlated with pain intensity felt during training runs ($r = .39$), the percentage of training days with run-induced pain ($r = .23$), the highest intensity pain ever experienced ($r = .23$), the number of prior marathons run ($r = -.18$), and relative exercise intensity as indexed by perception of effort ($r = .11$) (all $p < 0.001$). The relationship between pain and perceived exertion was higher after statistically controlling for variation in the time to complete the 26.2 mile run ($r_{12,3} = .18$). The significance and strength of these bivariate associations did not change in partial correlation analyses that statistically accounted for the number of weeks since the last marathon was run.

Discussion

Pain threshold

On average, runners reported pain starting between mile 15 and 16 of the marathon. However, there was substantial variability in the onset of pain during a marathon, ranging from within the first mile to the last mile of the race. Substantial inter-individual variability characterizes pain threshold measures even when standardized noxious stimuli are presented to a homogeneous group in a lab setting, including pressure, thermal and cycling exercise stimuli (7, 8). Thus, it was not surprising that there was substantial variability in the mile at which pain was first experienced during a marathon run, especially given that the absolute exercise stimulus was not the same for every participant because of variations in, for example, race course elevation.

Pain location

The fact that pain was experienced most frequently in the thigh, hamstring and calf muscle groups is consistent with prior reports of hamstring and calf injuries among marathon runners (9). The hypothesis that most runners (> 50%) would experience pain during the marathon was confirmed. Indeed, only 2 of 1251 runners reported feeling no pain during a marathon. These data indirectly support the idea that pain is not a primary constraint on human endurance performance (10). For example, ultramarathon runners can continue to endure for 100 or more miles per day despite the presence of pain (11). It may be possible for a higher percentage of participants to run a pain-free marathon if they are well trained for the task, if they take strategic walking breaks and if a key goal is to run at a pace that avoids pain. It is unknown how many people who participate in a marathon, run with a primary goal to avoid pain. The motivations for running were not assessed among the participants in the present study. Individuals train for and run marathons for a host of reasons, including to lose weight, to increase physical fitness, to give life meaning, to help cope with life's problems, to socialize, to achieve a goal and others (12, 13). Certain types of goal achievement motivations, such as running a fast time, are inconsistent with avoiding pain.

Hypothesis of moderate intensity pain for most runners

The hypothesis that most people would experience moderate intensity pain during the marathon was not confirmed. The average pain intensity at the primary location of pain represented pain that was "strong"; that is, more intense than moderate but less than the highest intensity pain ever experienced which in this study approached the extremely intense category of the 0–10 scale used. About two thirds of the sample reported overall pain that ranged from 3 (moderate) to 7 (very strong). One of the few prior studies that measured pain associated with marathon running queried 127 participants in a marathon in Kraków, Poland and found that recalled pain intensity of the marathon one week or one month after the marathon averaged between 5 and 6 on an 11-point numerical scale (14). These observations are generally consistent the present findings. The prior study manipulated the timing of the recall post-marathon and compared participants who were, and were not, experiencing pain during the recall period. The authors concluded that pain intensity experienced during a marathon run is underestimated one month after the

marathon compared to a week after, and is mediated by the pain experienced when the recall is made (14). No direct comparison can be made between this prior smaller study and the present larger study because of methodological and study aim differences. In the present study, however, the presence or absence of pain during the recall was not obtained and the time since the last marathon varied. The time since the last marathon was measured in the present study and removing the influence of that variable did not significantly change the strength of associations based on partial correlation analyses.

Hypothesized correlates of pain intensity during a marathon

It is not surprising that, as hypothesized, the intensity of pain during training and the percentage of training days in pain were significantly related to pain during the marathon because whatever caused the pain during training, such as an injury, hilly training routes or simply high intensity effort, could have carried over to race day. Other plausible variables that could account for the pain intensity experienced during a marathon run, beyond running-related variables such as prior aerobic training (15), physical fitness (16), injury status (17), the intensity of effort (18) and the extent to which the marathon course had elevation changes, include genetics (19), family history of hypertension (20), typical sleep duration (21), health status and biological sex.

It is unclear why the average pain intensity during the marathon was positively correlated with the highest intensity pain ever experienced. While speculation about masochistic and addictive elements of long distance running are perhaps relevant (22), future research is needed to understand this finding. Possible explanations for the negative correlation between the number of prior marathon runs and pain during the marathon appear more straight forward. Multiple psychophysiological adaptations from training for, and competing in, marathon runs serve to reduce pain and effort perceptions associated with the marathon (23).

Not surprisingly, and as hypothesized, effort ratings were positively correlated with the average pain intensity experienced during the marathon run ($r = .11$) and the magnitude of the relationship was higher after controlling for run time ($r_{12,3} = .18$). Pain and effort are conceptually and empirically positively related; exerting more effort results in running faster which increases the likelihood of higher intensity pain. The magnitude of these relationships, however, can be influenced by a host of variables including whether one is running uphill or downhill (24), recent prior run training (25), exercise duration (26) and health status (27). Most of the available data about pain and perceived effort during exercise comes from studies of indoor cycling. Thus, the present study adds novel data to the small literature on pain, effort and marathon running.

Hypothesized sex-related differences

On average, females did report higher average pain intensity at the primary location of their pain sooner in the race than males by an average of 0.3 raw pain score units, however, the magnitude of this difference was not enough to support the hypothesized sex-related difference in this variable even after adjusting for the sex-related difference in effort. The observation of lower effort ratings, on average, for

the female sample compared to the males is consistent with prior studies showing that females often exercise at a lower intensity than males and more frequently engage in physical activity modes that are less strenuous (28, 29). In marathon running, however, women maintain a steady pace to a greater extent than men and this plausibly could contribute to lower effort ratings, though the reason for this sex-related difference is unknown (30).

Limitations

Like all research, this investigation had limitations. The study was not controlled in a way that each runner ran the same course; consequently, error variance in estimating pain intensity during the marathon potentially was increased because of differences in the courses run. The survey was not a random sample from a well-defined population of marathon runners. Therefore, the findings may not generalize to other samples of marathon runners. Nonetheless, the findings contribute to the literature because the participants ran in over 250 different marathons and no similar data exist. Comparisons between females and males were imperfect because they were not based on samples carefully matched to avoid confounding variables such as the course run, prior training, running speed and many other variables that could have influenced pain intensity.

Conclusion

The present study shows that a marathon run is associated with moderate pain for most runners. This type of acute pain is independent of biological sex, and tends to be worse among those reporting more pain during training, less marathon experience, higher effort and higher intensity of the worst pain ever experienced.

Declarations

Abbreviations - CI: confidence interval; SD: standard deviation

Ethics approval and consent to participate - The study was approved by the University of Georgia IRB. Every participant was required to acknowledge that they had read an informed consent document and agreed to consent to participate in writing by providing their name and email address in a text box and clicking to agree.

Consent for publication – not applicable

Availability of data and materials – the data are available from the author upon reasonable request

Competing interests - The author declares he has no competing interests

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Authors' contributions - PJO designed and conducted the study, analyzed the data and wrote the article.

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Figures

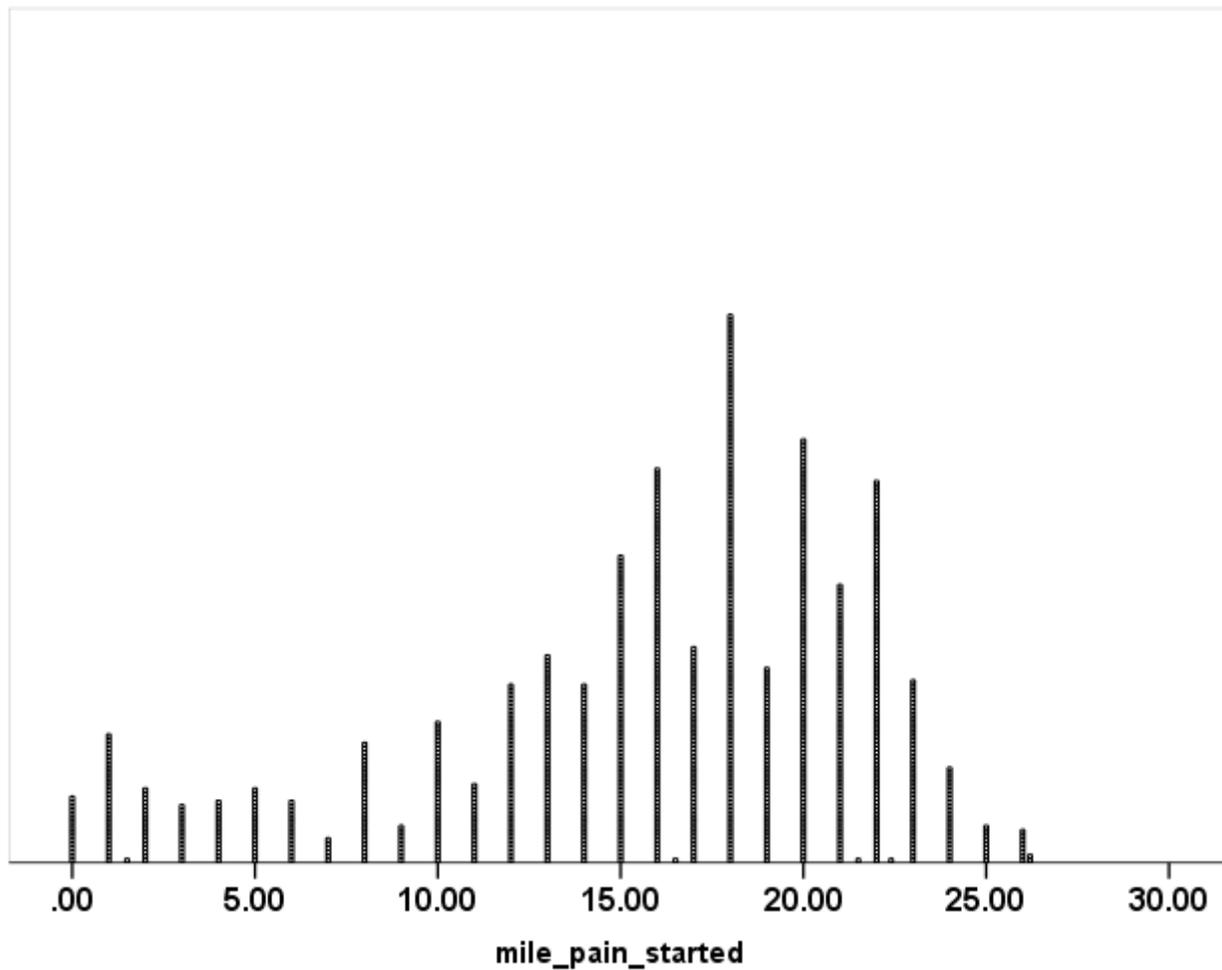


Figure 1

Frequency distribution of the mile at which pain was first experienced during a marathon.

Supplementary Files

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- [OConnormarathonpainsurveywith41questions.doc](#)