Injury Patterns and Levels of Care at a Marathon

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Abbreviations:
IV = intravenous

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Abstract

Introduction: Marathons pose many challenges to event planners. The medical services needed at such events have not received extensive coverage in the literature.
Objective: The objective of this study was to document injury patterns and medical usage at a category III mass gathering (a marathon), with the goal of helping event planners organize medical resources for large public gatherings.
Methods: Prospectively obtained medical care reports from the five first-aid stations set up along the marathon route were reviewed. Primary and secondary reasons for seeking medical care were categorized. Weather data were obtained, and ambient temperature was recorded.
Results: The numbers of finishers were as follows: 4,837 in the marathon (3,099 males, 1,738 females), 814 in the 5K race (362 males, 452 females), and 393 teams in the four-person relay (1,572). Two hundred fifty-one runners sought medical care. The day's temperatures ranged from 39 to 73°F (mean, 56°F). The primary reasons for seeking medical were medication request (26%), musculoskeletal injuries (18%), dehydration (14%), and dermal injuries (11%). Secondary reasons were musculoskeletal injuries (34%), dizziness (19%), dermal injuries (11%), and headaches (9%). Treatment times ranged from 3 to 25.5 minutes and lengthened as the day progressed. Two-thirds of those who sought medical care did so at the end of the race. The majority of runners who sought medical attention had not run a marathon before.
Conclusions: Marathon planners should allocate medical resources in favor of the halfway point and the final first-aid station. Resources and medical staff should be moved from the earlier tents to further augment the later first-aid stations before the majority of racers reach the middle- and later-distance stations.

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Introduction

Marathons pose many challenges to event planners. As category-III mass gatherings (i.e., unbounded, unfocused events) (Table 1),[1,2] marathons involve a large number of participants (in contrast to category I or II events, which mostly involve spectators) and are considered "mass participation endurance events."[1,3] Marathons are becoming increasingly popular, with 1,500 road races held each year throughout the United States.[4] This increase in popularity also has been observed in the United Kingdom, and has been associated with more novice runners per race.[5]

The medical services needed at such events have not received extensive coverage in the literature. The study described in this article examines injury pattern and medical usage data from a multi-event marathon, held in a metropolitan area in October 2001. Observations from that event are combined with information from published reports from similar mass gatherings, with the goal of assisting event planners as they organize medical resources for large public gatherings.

	Category I	Category II	Category III
Characteristics	Short (<6 hour) duration; spectators seated	Spectators mobile in a defined area	Spectators and participants "unbounded" in a large area
Examples	Football games, concerts*	Golf tournaments, outdoor papal masses	Marathons, triathlons

Table 1—Categories of mass gatherings
*Outdoor concerts with a seating area and an open area are Class 2 events.
Based on Sanders AB, Criss E, Steckl P, Meislin HW, Raife J, Allen D: An analysis of medical care at mass gatherings. *Ann Emerg Med* 1986;15(5):515–519 and Milsten AM, Maguire BJ, Bissell RA, Seaman KG: Mass-gathering medical care: A review of the literature. *Prehospital Disast Med* 2002;17(3):151–162.

First Aid Station	Location	Resources	Runners Treated	Received Intravenous Fluids	Received PO Fluids
A	Start/Finish Line	2 physicians 2 nurses 2 paramedics 3 EMTS 1 volunteer 3 ambulances	166	22	43
B	Mile 4	1 physician 1 nurse 1 ambulance	0	0	0
C	Mile 10	1 physician 1 nurse 1 ambulance	11	0	0
D	Mile 14	1 physician 2 nurses 1 volunteer 2 paramedics/EMTs	35	0	8
E	Mile 20	1 physician 2 nurses 2 paramedics 1 volunteer 1 ambulance	40	2	2

Table 2—First aid station locations, staffing, numbers of runners treated, and fluid administration. In addition to the medical personnel listed in this table, the marathon medical staff included an overall EMS coordinator, a nurse coordinator, two medical directors, and three operations assistants. A central communications center was set up at the start/finish line. Medical personnel communicated on radios (with repeaters).

Methods

This marathon consisted of multiple events, including a 5K run, a 26.2-mile marathon for individual runners, and a four-person marathon relay. Start times were staggered, beginning at 08:30 hours (h). The course, considered rolling and hilly, traversed the city, ranging from sea level to its highest elevation at 406 feet (123.7 m) at mile 16.

Five first-aid stations were set up along the route. Their locations and staffing patterns are listed in Table 2. A communication center was set up at the finish line to coordinate radio traffic among the medical providers, race staff, and police. This center was equipped to interface with the city's emergency medical services to facilitate transport to local hospitals if necessary. The medical care reports for all patients presenting to the first aid stations were reviewed, utilizing only descriptive statistics for reporting. The need to obtain consent was waived by the institutional review board at the academic medical center with which the authors were affiliated.

A standard first aid information collection form was used for this event (Appendix). All identifiers were removed for the purposes of this study. All forms were collected and sorted by one of the authors (AMM), who abstracted the data. Data on patients transported to hospitals were obtained through hospital medical records and from same-day interviews with emergency department charge nurses. Nurses or physicians completed the data forms in the first-aid stations.

Medication request	66
Musculoskeletal	45
Dehydration	32
Dermal injury	29
Dizziness	25
Bandage request	15
GI complaints	14
Headache	5
Other medical	5
Abdominal pain	4
Chest pain	3
Altered mental state	1
Diabetes related	1
Epistaxis	1
Foreign body	1
Hypo/hypertension	1
Insect bite	1
Respiratory related	1
Syncope	1

Table 3—Number of patients in each diagnostic category (primary and secondary reasons combined) (n = 251)

Weather data were obtained from the National Climatic Data Center.[6] The ambient temperatures ranged from 39°F (3.9°C) at 06:54 h to 73°F (22.8°C) at 14:54 h, with a mean value for the ambient temperatures of 56°F (13.3°C).[7] The temperature at 07:54 h, shortly before start time, was 43°F (5.6°C). The average dew point temperature was 42°F (6.1°C), with an average humidity of 68%. Apparent temperatures (heat index) could not be calculated, as they are inaccurate for ambient temperatures below 70°F (21°C).[8]

The diagnostic categories outlined by Mear and Batson were used,[9] with additions (altered level of consciousness) from Grange.[10] The Mear/Batson heat/cold-related category was divided further into heat exhaustion, heat stroke, and hypothermia.

If more than one complaint was noted on the medical report form, the most immediate reason the patient sought medical care was considered the chief complaint. The primary diagnosis was taken directly from the first aid sheets. If no primary diagnosis was listed, the investigators assigned their best estimate based on the chief complaint and first aid narrative.

The level of care was determined with the treatment categories used by Grange[10] (minor care, <5 minutes; basic care, 5–15 minutes; advanced care, >15 minutes), with the following alteration: patients requesting medication or a bandage (recorded on a medication request form, not a first aid form) were assigned to the minor category.

Physicians and nurses could dispense medications. The protocol used at these facilities stated that if a patient requested medication for a traumatic injury or if the case appeared to be serious (as judged by the triage nurse), a first aid form had to be completed. Basic or advanced care was assigned based on the amount of time the patient was in the first aid tent.

Medical usage was reported as a rate (patients per 10,000), which was calculated by dividing the number of individuals seeking medical care by the total attendance for the event and multiplying by 10,000, in order to maintain consistency with other published reports.

Results

An estimated 11,000 entrants competed in the three events.[11,12] The numbers of finishers were as follows: 4,837 in the full marathon (3,099 males and 1,738 females), 814 in the 5K race (362 males and 452 females), and 393 teams in the four-person relay (393 x 4 = 1,572). For the rest of the results and discussion, "marathon" refers to all three of the above-mentioned races, unless otherwise indicated.

Two hundred fifty-one runners sought medical care at the first aid stations (Table 3). Injury patterns were delineated by the primary and secondary reasons for seeking medical care. The most common primary reasons were medication requests (26%) (acetaminophen and ibuprofen), musculoskeletal injuries (18%), dehydration (14%), and dermal injuries (11%). The most common secondary reasons were musculoskeletal injuries (34%), dizziness (19%), dermal injuries (11%), and headaches (9%). For the purpose of analysis, primary and secondary reasons were combined.

Most injuries sustained by runners were minor (49%). Treatment times ranged from 3 to 25.5 minutes. As the day progressed, the treatment time lengthened. The longest average treatment time occurred between 15:00 and 15:59 h (Figure 1).

The start/finish line station (A) was the busiest of the five stations, and the middle tent had the second highest volume. Two-thirds (n = 166) of the people who sought medical care presented to medical personnel at the end of the race. At all stations, most patients sought medical attention between 12:00 and 12:59 h.

Of the 4,837 full marathon finishers, 64% were male and 36% were female. In regard to the 252 people seeking medical care, 62% were male and 38% were female. Those seeking medical care had a wide age range (18 to >60 years). Most runners were between the ages of 26 and 45 years. The majority of runners who sought medical attention had not run a marathon previously (22%). The majority of runners trained by running 10 to 49 miles a week.

Treatment times in the first-aid stations increased with time of day. One contributing factor was that most runners who required intravenous (IV) fluids received them at the finish-line station. It makes sense for hydration to be greatest among runners who have run for the longest times and farthest distances. Among runners who sought any type of medical treatment, 30% received fluids. Of note, 84% of hydration therapy was given at the finish-line station. One-third of the runners who received hydration therapy received IV fluids, and 22 of the 24 runners who received IV fluids received them at the finish line.

The majority of patients were seen between 11:00 h and 15:00 h. This logical peak probably is related to rising temperatures as the day and the race progressed (the day's maximum of 73°F [22.8°C]) occurred at 15:54 h) as well as the culmination of runners' fatigue and medical symptoms/complaints. As stated earlier, planners of future events should consider increas-

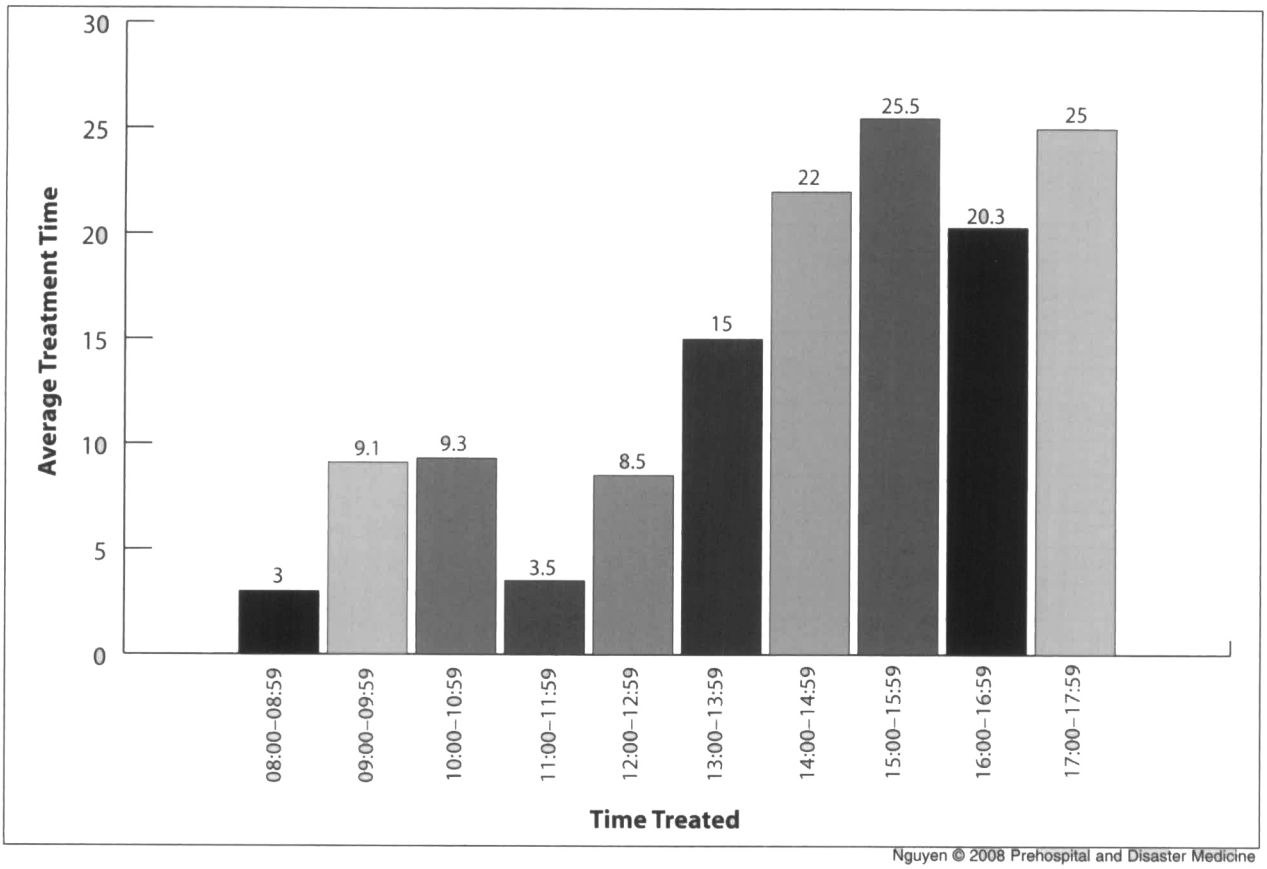

Figure 1—Length of medical treatment times relative to time of day. Average treatment times are in minutes.

ing medical staff in the later first-aid stations by shifting staff members after most runners have passed the earlier stations.

During the marathon discussed in this article, 17 people were transported to hospitals, and two of them were admitted. The transfer-to-hospital rate was 15 per 10,000 runners entered.

Discussion

Marathons continue to grow in popularity. The USA Track and Field Road Running Information Center[4] estimates a 3% increase in overall marathon participation in the US from 2002 to 2003, and a 7.5% increase in finishers between 2003 and 2005. With an estimated 10 million regular runners in the US, and 800,000 to 1 million runners entering competitive races each year, running has become and continues to be a popular form of exercise.[13]

Among runners, marathon participants in particular face a variety of hardships that can result in injury or death during a race. These factors include the rigorous training that many athletes endure before the marathon. Among participants in a 10,000-meter race, Jacobs found that training factors such as running >30 miles/week or >5 days/week were associated with injury incidence.[13]

During a race, a number of environmental factors expose runners to injury. Temperatures may vary widely as the day progresses, so, depending on factors such as wind chill and humidity, runners could be exposed to cold- and heat-related threats during the same race. The incidence of injuries and illness tends to rise with increasing environmental temperature.[14] Hypothermia, hyperthermia, heat stroke, and frostbite are well-documented among marathon runners and should be anticipated by event planners and medical care providers at any marathon.[15] Despite the rigorous training, aerobic activity, and the variety of medical and environmental challenges that marathon runners face, running still is a safe sport.[16–18] The factors affecting marathon participants can be viewed through Arbon's three-part conceptual model, with its biomedical, environmental, and psychosocial domains.[19] Specifically, a runner's potential for morbidity and mortality could be related to motivation, length of run, illicit substance use (psychosocial domain); medical history, age, training level (biomedical domain); and crowd density, terrain, and weather (environmental).

Event planners and medical care providers should be aware that the tactical use of medical resources such as staff, water stops, and first-aid stations could maximize the delivery of medical care to those in most need, as well as decrease the number of ambulance transports to emergency departments.[16,18] Richards *et al* studied successive marathon injury patterns and incidences over several years and correlated that information with the corrected effective temperatures.[20] They could predict the number of injuries in subsequent races, with the goal of allocating adequate medical personnel and resources in the most effective manner and not wasting materials and supplies. This approach was corroborated by Roberts, who stated that "anticipation of casualty severity

and frequency allows the medical team to concentrate staff recruitment and training in the areas of greatest need."[18]

The marathon described in this article yielded data that could be useful to future marathon planners. Most marathon runners who sought medical care did so at the finish line. There could be several reasons for this, including psychological ones. Runners have a strong drive to finish the race and may ignore their symptoms or medical needs until they reach the finish line. Masters[21] and Stevinson and Biddle[22] report cognitive dissociation in runners, whereby they "cut themselves off from the sensory feedback they would normally receive from their body." Furthermore, a "runner's high" has been reported,[21,23] though the definition of this experience remains unclear. These psychological phenomena, coupled with the concept of "hitting the wall," could explain why runners physically push themselves. According to the lay press as well as academic sources,[22,24] "hitting the wall" is a point of maximum fatigue that occurs around the 20-mile mark, when runners' carbohydrate reserves are depleted and their bodies switch to metabolism of fat for energy.

In addition, spectators tend to congregate at the finish line to watch the runners at the end of the race. The spectators themselves could be subject to dehydration, fatigue, and headaches after standing outside for several hours and thus, require medical assistance. Interestingly, the first-aid station at the halfway mark for the marathon was the second busiest. Injury patterns at this station were similar to those at the busiest station. For these reasons, event planners should be aware of the variety of medical needs that become evident at the end of a long race and should staff the middle and final stations more heavily than the others. During the race, it is logical to move medical providers to the sites where they are needed most, which will utilize limited medical staff most effectively.

In this study, the most common reason runners came to the first-aid stations was to request medication (26%). During the marathon, 52% of runners sought care related to medical needs (dehydration, fatigue, cramps), which is lower than Milsten's findings for category I events (baseball games [71%] and football games [74%]). Marathon finishers presented with more traumatic injuries (sprains, strains, and blisters [42%]) than did spectators at baseball (26%) and football games (29%). On the other hand, rock concerts without mosh pits (categories I and II) had surprisingly similar findings to the 2001 marathon results: 58% of people who sought medical care had medically related diagnoses, and 42% had trauma-related conditions.[25]

In this study, 3.5% of race finishers sought medical care, with a patient presentation rate (PPR) of 228 per 10,000 runners entered. These numbers are similar to those reported by Roberts,[18] who studied the Twin City Marathons held between 1983 and 1994, in which 189 entrants per 10,000 and 253 race finishers per 10,000 sought medical care. Also, the data from the current study were similar to those of Grandma's Marathons held between 1990 and 1995,[3] for which 6.8% of finishers presented at medical tents.

One of the runners who was transported to a hospital died in the receiving emergency department. The cause of this 29-year-old woman's death was brain ischemia; due to HIPPA laws, further information could not be obtained. She was transported by ambulance directly from the scene without being taken to a first aid station. The marathon's emergency medical services system was not activated for this emergency since the runner had collapsed between two first-aid stations, and a bystander called 9-1-1. This death during the marathon translates to a mortality rate of 1.38 per 10,000 race finishers (0.9 per 10,000 race entrants), which is higher than the 1 in 50,000 finishers reported by Maron and associates during their study of the Twin Cities and Marine Corps marathons.[17]

Limitations

The results documented in this study are limited by the fact that they are derived from a single event. The number of runners who needed medical assistance could be higher than reported, because it is possible that those who needed medical assistance obtained it from sources other than the first aid stations. Also, even though the need for documentation was stressed to the medical staff, it is possible that report forms were not generated for some patients during busier times in the first aid tents. This shortfall was mitigated by using volunteers (instead of medical staff) to record patient information upon arrival.

Finally, if a small percentage of patient visits were not recorded, those visits likely would have been for minor medication or bandage requests. Furthermore, the number of medical conditions treated could be under-estimated based on the decision to *a priori* define only the primary and secondary reasons for presentation. Future studies are required to identify other factors that may influence the utilization of medical resources, such as ambient temperature, weather conditions, and geographic elevation, in order to provide event planners with additional useful information to guide the strategic placement of healthcare resources at category III mass gatherings.

Conclusions

The marathon described in this article was a relatively safe event. Most injuries were minor and most runners who sought medical care were discharged. Runners tended to seek medical care 3 to 5 hours into the race. The first-aid station at the finish line had the highest patient volume of all five stations. This final station dispensed the most hydration, the majority in the form of oral fluids.

Marathon planners and the providers of medical care at these events should allocate their resources to the later first-aid stations, especially the station at the finish line during early afternoon. Planners also should consider heavier staffing at the first aid station at the halfway point of the marathon. Resources and staffing can be moved from the tents located toward the beginning of the race to augment the first aid stations at the middle and end of course.

Acknowledgments

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Appendix—Medical report form

Marathon Medical Report Form
October 20, 2001

Name:_____
First Last
Station: _____ Race #: _____
Time In: _____ Age: _____
Circle appropriate choice for each patient:
Male/Female. Recent Alcohol/Drug Use – Yes/No
Spectator / Full Marathoner / Relay Runner / 5K / Walker
Previous Training: # of previous marathons/races _____
# of miles run per week: _____
Mechanism of Injury: Running / Fall / Other _____
Chief Complaint:_____
Medical: If more than one is checked, circle the primary problem.

☐ Medication Request	☐ Eye Complaints
☐ Abdominal Pain	☐ Cardiac Arrest
☐ Chest Pain	☐ Dehydration
☐ Diabetes Related	☐ Dizziness
☐ Epistaxis GI	☐ Complaints
☐ Headache Heat	☐ Exhaustion
☐ Heat Stroke	☐ Cold Related
☐ Hypo/Hypertension	☐ OB/GYN
☐ Respiratory	☐ Related Seizure
☐ Syncope Altered	☐ Mental State
☐ Allergy Related	☐ Cardiac Arrhythmias

Check one from each column below. Add others as needed.
Dermal = abrasion, laceration, blister. MK = sprain, spasm, pain, fracture, bruise.

Trauma:	Location of Injury:
☐ Bandage Request	☐ Head or Neck
☐ Dermal Injury	☐ Torso
☐ Foreign Body	☐ Upper Extremity
☐ Insect Bite	☐ Lower Extremity
☐ Muscule-Skeletal (MK)	☐ Other Trauma_____
☐ Closed Head Injury	☐ Other Medical _____
☐ Stabbing/GSW	☐ Sports Massage/Med.

HPI: _____
Allergies: /NKDA Vital Signs:
Treatment:

Medication & Dose: Time Given:
Disposition: Discharge / Transport / Other _____
Comments: _____
Time Released: _____
Treated By: Print & Sign _____

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