Manuscript title

Risk factors for not finishing an ultramarathon: 4-year study in 23996 race starters, SAFER XXI

Running Title:

Risk factors for not finishing ultramarathon

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ABSTRACT

BACKGROUND: Limited data support pre-race medical screening to identify risk factors for not finishing an endurance running race. The aim of the study was to determine risk factors associated with not finishing an ultramarathon.

METHODS: A prospective, cross-sectional study of Two Oceans ultramarathon (56km) race starters who completed a pre-race medical screening questionnaire. Race day environmental conditions were recorded on race day. Univariate analyses of risk factors associated with the did-not-finish (DNF) included race day factors and pre-race medical screening history.

RESULTS: Risk factors for DNF amongst 23996 starters during the 56km race included older age and being female ($p<0.0001$). After adjusting for age and sex, the following were significant univariate risk factors: fewer years of running ($p<0.0001$), less previous race experience ($p<0.0001$), less training / racing per week ($p=0.0002$), lower average weekly training distance ($p=0.0016$), slower race vs. training speed ($p<0.0001$), lack of allergies ($p=0.0100$) and average wet-bulb globe temperature ($p<0.0001$).

CONCLUSION: Females, older age, training-related factors (less training / racing, average weekly training distance, race vs. training speed) and average wet-bulb temperature, were risk factors for not finishing an ultramarathon. The results may not only assist runners and coaches in race preparation, but also have clinical implications for the medical planning prior to races.

Key words:

Running, endurance sports, risk factors, race performance, pre-race screening, medical screening, adverse events, SAFER study

Introduction

The prevalence of non-communicable diseases (NCDs) in the general population is increasing, and in turn, preventative measures to combat these NCDs are needed [1,2]. Regular physical activity is a highly effective non-invasive preventive measure for NCDs, and therefore is advocated [3].

Promoting physical activity is associated with increased participation in mass community-based sport events which has increased the risk of medical encounters during and after endurance sports events [4-6]. Risk factors for medical encounters have been investigated and include: less experienced runners, slower running pace and older females [7,8]. Pre-race acute illness has also been associated with adverse events in two studies [9,10].

However, with ultramarathon running, medical encounters are not the only “adverse events” that can occur. Starting but not finishing the ultramarathon is a common occurrence. In the Two Oceans 21.1km race 1.1% did-not-finish (DNF), whereas in the 56km 4.0% DNF illustrating the difference in completion rates between a half-marathon and an ultramarathon [4]. Whilst less serious for the runner and medical staff, not finishing a race places a burden on the runner and the race organizers (transport of runners to certain access points, or to the end of the race), and therefore the risk factors associated with DNF is of importance to aspiring runners, coaches and race organizers. Training-related factors (e.g. training distance, frequency) are previously reported predictors of participants having a medical complication or injury [7,10]. However, very little research on race performance exists [11] and should be investigated.

With access to more detailed individual race entrant pre-race medical histories, further risk factors associated with not finishing the race, such as the pre-race medical risk profile, could potentially be identified. Using this information, participants could better prepare for ultramarathon participation, and improve their chances of completing the distance. The medical planning prior to races could benefit from identifying risk factors.

Thus, the aim of the present study is to determine risk factors that are associated with not finishing the race in ultramarathon (56km) runners during mass community-based running events using a pre-race medical screening questionnaire and race day factors.

Materials and methods

Study Design

A cross-sectional study of data collected prospectively over a 4-year period (2012-2015).

Participants and data collection

This study forms part of a series of studies known as the SAFER (**S**trategies to reduce **A**dverse medical events **F**or the **E**xercise**R**) studies. Potential participants for this study were all entrants for the 56km Two Oceans Ultra-Marathon race, which is a mass community-based running event in South Africa. In each of the 4 years, the race entrant data (demographic data) and race-day data (number of starters and finishers) were obtained, with permission, from the race organizers. Demographic and race data are in the public domain and are available on the race website. Entries for the 56km race required a sub-5 hour 42.2km-qualifying time (verified by records). Entrants, defined as any runner registering for the races (registration typically opens 3-5 months before the races), over a 4-year period (2012-2015) were considered as participants.

Pre-race medical screening data

During the study period (2012-2015), an online pre-race medical screening and an educational intervention was implemented for all race entrants [12]. Previously described in detail, the data collection consisted of information obtained from a compulsory pre-race medical screening questionnaire or "self-assessment of risk" [12]. The pre-race medical screening questionnaire was based on the European Association for Cardiovascular Prevention and Rehabilitation (EACPR) recommendations and consisted of the following main categories: history of chronic diseases and risk factors (symptoms of CVD, risk factors for CVD, history of CVD and history of other chronic disease), general prescription medication use, medication use during racing, history of injury and a past history of collapse during racing [12,13]. The screening questionnaire also included a section on training history. Upon completion of the questionnaire, participants were given the opportunity to consent to their data being used for research purposes. No participant was prevented from participating in the race by race organizers or the medical team, and the final decision to run on race day was left up to the athlete and his/her medical practitioner.

The Research Ethics Committee of the University of Cape Town (REC 009/2011 and REC R030/2013) approved the protocol and the Research Ethics Committee of the University of Pretoria (REC 433/2015) approved the on-going data collection, and subsequent analysis of the data.

Risk factors associated with did-not-finish

The outcome was the did-not-finish (DNF: runners starting but not finishing the race). We included the following potential risk factors in our model: demographic variables, training and racing variables, pre-race medical screening for history of chronic disease and race day environmental data (all data was available on an individual level for all who participated, except environmental).

Demographic variables included age and sex, while training and racing variables were as follows: years of recreational running (years), distance running events (years), previous 56km race experience (part of the entry database), frequency of training or racing per week, actual race speed in kilometer/hour derived from race day data, average self-reported training pace (km/h). In addition, we calculated the race speed / training speed ratio (RS/TS) to derive a new variable to describe the runner's chosen race pace relative to the training pace. A value > 1 for this variable indicates that a runner races at a speed that is faster than the usual self-reported training speed. This measure depicts the "relative" running speed of a runner on race day.

Pre-race medical screening variables included: a chronic disease composite score (out of 10), which is a continuous variable of the sum of an individual's answer to 10 questions related to a history of chronic disease (CVD risk factors, CVD symptoms, CVD history, metabolic/endocrine, respiratory, GIT, nervous system/psychiatric, kidney/bladder, hematological/immune, cancer), history of allergies, a past history of collapse during training or racing, and a history of a recent (<12 months) running injury.

For race day environmental data, race day hourly data between 6 AM and 12 PM from one weather station along the route to calculate average wet-bulb globe temperature (aWBGT) was collected. This was included as a parameter of environmental conditions, known to affect medical encounter rates during events [14-16].

Statistical Analysis

All analyses were done using the SAS (V.9.4) statistical analysis system. Modified Poisson regression models using a robust error estimator (log link function) to estimate the Incidence rate ratios (IRR) and 95%CIs, which was calculated as the measure of association to analyze the DNF outcome. The correlated structure of the data, due to the same athletes taking part in several years over the 4-year study period, was accounted for by using an exchangeable correlation matrix. Incidence rates (IR) (per 1000 starters and 95%Cis) as well as unadjusted and adjusted univariate incidence rate ratios (IRR) (per 1000 starters and 95%CIs) of Demographic variables, Training and Racing variables, Pre-race medical screening variables and an Environmental variable are reported for DNF. The adjusted univariate models were adjusted for age and sex. aWBGT (representing the environmental conditions) was included in the model as a categorical variable, as there were only 4 individual values (i.e. one for each year). The statistical significance level was 5%, unless specified otherwise.

Results

Race entrants, consenting race entrants and race starters

Out of the 42003 entrants over the four years, 29585 gave consent, for their pre-race medical screening data to be used for research purposes. Of these, 23996 (81.1 % of all entrants) started the race and formed the final study population.

The sex and age profile of all race entrants, consenting race entrants, race starters, non-finishers and medical encounters in this study is shown in Table I.

Table I: The profile of all race entrants, consenting race entrants, race starters, non-finishers and medical encounters in this study by sex and age group.

		All race entrants (n=42003)		**Consenting race entrants (n=29585)**		**Starters participating in this study (n=23996)**		**Did-Not-Finish (n=1032)**	
		n	%	N	%	n	%	n	%
Sex	Males	30466	72.5	21044	71.1	17154	71.5	655	63.5
	Females	11537	27.5	8541	28.9	6842	28.5	377	36.5
Age (years)	≤30	4953	11.8	3574	12.1	2781	11.6	101	9.8
	31-≤40	15181	36.2	10755	36.4	8675	36.2	313	30.3
	41-≤50	14254	33.9	10078	34.1	8312	34.6	335	32.5
	>50	7615	18.1	5178	17.5	4228	17.6	283	27.4

The sex and age profiles of the all race entrants, consenting race entrants and starters participating in this study were similar.

Risk factors associated with the Did-Not-Finish (DNF) rate (unadjusted and adjusted)

The overall did-not-finish (DNF) rate was 44.5 (95%CI: 41.8 to 47.4) per 1000 starters. The risk factors for DNF are presented in Table II (univariate and adjusted analysis).

The following unadjusted univariate risk factors were found to significantly increase the risk of DNF: female, older age, less previous race experience, training variables (slower race speed vs. training speed, reduced training or racing frequency per week, lower weekly training distance), an increased number of chronic diseases, reporting no allergies, prescription medication use and aWBGT (inverted U association).

Further analysis on the age and sex interaction and the association with DNF was also significant ($p=0.0085$). For males, the >50years vs ≤30years were at increased risk (IRR=1.8 (1.4-2.5)) ($p<0.0001$), and similarly for females; >50years vs ≤30years, IRR=2.0 (1.3-3.0) ($p=0.0013$).

After adjusting DNF for age and sex, seven univariate risk factors were still associated with an increased DNF rate. The significant training-related risk factors were: fewer years of running ($p<0.0001$), less previous race experience ($p<0.0001$), less training/racing per week ($p=0.0002$), lower average weekly training distance ($p=0.0016$) and slower race vs. training speed ($p<0.0001$). A lack of allergies ($p=0.0010$) and aWBGT (inverted U-shaped relationship) ($p<0.0001$) were significant factors associated with an increased DNF rate. After adjusting for age and sex, chronic disease, was no longer significant ($p=0.1312$).

Table II: The did-not-finish (DNF) rate (per 1000 starters: 95% CI) during the race per risk factor from the pre-screening medical questionnaire and race day data (n=1032)

Risk factor variables		Did-Not-Finish			Univariate Unadjusted		Univariate adjusted for age and sex	
		Rate (Per 1000 starters)	95% CI		Incidence rate ratio (95%CI)	p-value	Incidence rate ratio (95%CI)	p-value
1. Demographic variables								
Sex	Males	39.5	36.5	42.8	0.7 (0.6-0.8)	<0.0001		
	Females	57.2	51.7	63.3	1.4 (1.3-1.6)			
Age (years)	≤30	37.2	30.4	45.6		<0.0001		
	31-≤40	37.6	33.6	42.0	1.0 (0.8-1.3)			
	41-≤50	41.8	37.5	46.5	1.1 (0.9-1.4)			
	>50	69.3	61.5	78.2	1.9 (1.5-2.4)			
2. Training and racing variables								
Years of recreational running (years)*	4	46.5	42.8	50.6	5 unit increase: 0.9 (0.9-1.0)	0.0804	5 unit increase: 0.9 (0.9-0.9)	<0.0001
	8.5	45.1	42.3	48.2				
	15	43.2	40.2	46.4				
Previous 56km Race Experience (medals)	0-1	52.2	48.3	56.5	1.4 (1.2-1.6)	<0.0001	1.9 (1.7-2.3)	<0.0001
	2-4	33.5	29.0	38.6	0.9 (0.7-1.1)		1.1 (0.9-1.4)	
	≥5	37.2	32.6	42.6				
Times Training or Racing per week*	3	48.1	44.2	52.4	1 unit increase: 0.9 (0.9-1.0)	0.0069	1 unit increase: 0.9 (0.9-1.0)	0.0002
	4	45.1	42.3	48.1				
	5	42.3	39.2	45.6				
Average weekly training/running distance in the last 12 months (km)*	20	50.5	45.3	56.4	5 unit increase: 1.0 (1.0-1.0)	0.0070	5 unit increase: 1.0 (1.0-1.0)	0.0016
	35	47.5	44.0	51.4				
	50	44.7	42.0	47.6				
Race Speed vs Training Speed (RS/TS)*	0.8	50.9	47.7	54.5	0.2 unit increase 0.6 (0.5-0.7)	<0.0001	0.2 unit increase: 0.6 (0.5-0.7)	<0.0001
	1.0	30.9	27.5	34.8				
	1.2	18.8	15.0	23.6				
3. Pre-race medical screening variables								
Chronic Disease Composite Score*	0	42.7	39.8	45.7	2 unit increase: 1.3 (1.1-1.5)	0.0078	2 unit increase: 1.1 (1.0-1.4)	0.1312
	2	54.7	47.3	63.4				
	4	70.2	52.0	94.9				
History of Cramping	Yes	49.6	43.9	56.1	1.1 (1.0-1.3)	0.0599	1.2 (1.0-1.4)	0.0360
	No	43.2	40.2	46.3				
Allergies	Yes	35.2	27.9	44.4	0.8 (0.6-1.0)	0.0224	0.8 (0.6-1.0)	0.0100
	No	45.4	42.6	48.5				
History of Collapse	Yes	36.4	21.2	62.2	0.8 (0.5-1.4)	0.4073	0.7 (0.4-1.3)	0.2685
	No	44.7	42.0	47.6				
Recent (last 12 months) running injury	Yes	39.6	33.4	47.1	0.9 (0.7-1.0)	0.1343	0.9 (0.7-1.0)	0.0790
	No	45.3	42.4	48.4				
4. Environmental variable								
aWBGT	12.1	44.1	38.6	50.4		<0.0001		<0.0001
	13.4	52.5	47.7	57.8	1.2 (1.0-1.4)		1.2 (1.0-1.4)	
	15.1	52.7	47.5	58.4	1.2 (1.0-1.4)		1.2 (1.0-1.4)	
	18.4	27.0	23.4	31.3	0.6 (0.5-0.7)		0.6 (0.5-0.7)	

p-value is reported for the overall factor

Race Speed (km/h) vs Training Speed (km/h) Ratio = race speed / training speed; a value >1 is a faster average race speed compared to average training speed; and a value <1 is a slower average race speed compared to average training speed

[#]Incidence Ratio is 0-1 vs ≥5, 2-4 vs ≥5

*a continuous variable

Chronic Disease Composite Score: the composite number of chronic diseases for an individual

aWBGT: average Wet-Bulb Globe Temperature, 12.1 was the reference value/year (2012)

Discussion

The findings of this study are that, when adjusted for age and sex, risk factors associated with a higher DNF rate were predominantly training-related (years of running, less previous race experience, less training/racing per week, lower average weekly training distance, slower race vs. training speed), but also included a lack of allergies and aWBGT (inverted U-shaped relationship). We believe these data are important for race organisers and medical staff, but could also add much value to coaches and runners attempting their first ultramarathon.

Our main finding was that training-related factors were associated with a risk of DNF. A slower race speed relative to the self-reported average training speed was a risk factor for DNF. This means that runners who ran at a much slower speed on race day, compared to their training speed, were more likely to not finish an event. This new variable used self-reported training speed and the ratio of this to the participant's race speed in the ultramarathon. In one multi-day ultramarathon study, the race completion time was not associated with medical encounters [17], and in the previous SAFER studies, conflicting results related to absolute race pace were found in the half-marathon and the ultramarathon runners [7,8]. Furthermore, it must be noted that race performance can also be influenced by factors such as the terrain where a participant trains versus the terrain of the race course and differences in elevation within the course. From the current information, it is not clear why a slower race speed vs. training speed is associated with an increased risk of DNF. We can only speculate that runners were not adequately prepared for an ultramarathon (i.e. their training pace was faster because they only trained for shorter distances) or that on race day they did not feel well/sustained a minor injury. Race pace compared to training pace and DNF risk needs to be further investigated. In the future, a more objective measure of participants' training pace should be used (i.e. using wearable technology) instead of self-reported data.

Further training-related factors associated with not finishing were: years of running, less previous race experience, less training/racing per week and average weekly training distance. The lack of previous race experience as a risk factor for DNF is in keeping with the previous data from the Two Oceans 56km ultramarathons, where less previous race experience was associated with increased risk of medical complications [7]. First time marathon entrants to the Auckland Citibank marathon were also at higher risk for injuries and medical complications during the event [10]. Naturally, we would expect that the first time ultramarathon runner would have a lower chance of completing the ultramarathon, compared to those on their fifth or more race. Injuries and weekly running volume (weekly training distance in our study) have not been investigated in association with not finishing a race, providing novel data for coaches and runners.

Being female and of older age are risk factors similar to our previous study findings where we found females and older aged participants had a higher risk of medical encounters, which could result in not finishing ultramarathons [8]. These data are important because currently races attract more older runners and females, and therefore the number of participants not finishing ultramarathons, could be increasing [19].

We also explored the relationship between environmental conditions and risk of DNF. In contrast to many reports [15,20,21], DNF was related to aWBGT within the narrow band of aWBGT values between 12.1 and 18.4 in an inverted U relationship. We note that the variation between the lowest and highest aWBGT over the 4 years was only 6.3°C. These values were all in the low risk category (aWBGT < 18) except for one year, where the value was in the moderate risk category (18.4). This value corresponds to the lowest risk in other races (e.g. Gothenburg)[14] in temperate climates, where higher WBGT is associated with higher risk [16]. Our results therefore cannot be compared to studies where the risk was high at a higher aWBGT (> 22) [15,22]. However, our results do suggest that the risk of DNF is related to aWBGT, not only in hot conditions [14], but also in relatively cooler conditions. The varying responses to WBGT can be due to a number of factors, one of which is individual athlete heat acclimation/acclimatization [23]. Heat acclimation is a proven heat mitigation strategy [23], and it is thought that potentially, participants who respond adversely to the varying WBGT (e.g. in the low risk category) had been training at an even lower temperature and had not acclimatized. This however requires further investigation, with more data from participants regarding their training WBGT, and a larger WBGT range.

Allergies were associated with a decreased risk of DNF. This finding is counterintuitive. The medication taken by athletes with allergies would be assumed to be a contributing factor to the role allergies play in injuries, however for allergies to assist in finishing an ultramarathon, is unknown to us. This could be a chance finding, and therefore this definitely warrants more data, and further investigation.

Runners and coaches could consider these risk factors for not finishing when preparing for ultramarathons. Race organisers and medical staff could also benefit, by using this information to prepare for anticipated number of runners that would do not finish the race and would need to be removed from the course during the event.

There are a number of strengths of this study. The data were collected prospectively over four years, and therefore includes a large sample size representative of all race entrants for sex and age group. The medical history and training history for each individual participant was extensive and allowed us to explore multiple variables. However, a limitation of the study is that the pre-race screening data, including the training data, was all self-reported. Other limitations include some race entrants did not consent to their data being used which may introduce selection bias, the study was cross-sectional, and cannot infer causation, the wet-bulb globe temperature was in a small range, the reasons for participants not finishing the race could not be provided. Our data are only applicable to populations that participate in ultramarathon events and may not be generalizable to races of shorter durations. It must also be noted that this population was exposed to an intervention during this period which targeted those with existing CVD, and those with symptoms/risk factors for CVD, which would have influenced the risk factors identified [12].

Conclusion

Females, older age, training-related factors and average WBGT (12.1-18.4, relatively low range) were factors associated with an increased risk for not finishing a distance running event.

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Conflict of Interest:

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Author Contributorship:

All authors read and approved the final version of the manuscript.

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