Personal Best Marathon Time and Longest Training Run, Not Anthropometry, Predict Performance in Recreational 24-Hour Ultrarunners

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Abstract

Knechtle, B, Knechtle, P, Rosemann, T, and Lepers, R. Personal best marathon time and longest training run, not anthropometry, predict performance in recreational 24-hour ultrarunners. *J Strength Cond Res* 25(X): 000–000, 2011—In recent studies, a relationship between both low body fat and low thicknesses of selected skinfolds has been demonstrated for running performance of distances from 100 m to the marathon but not in ultramarathon. We investigated the association of anthropometric and training characteristics with race performance in 63 male recreational ultrarunners in a 24-hour run using bi and multivariate analysis. The athletes achieved an average distance of 146.1 (43.1) km. In the bivariate analysis, body mass ($r = -0.25$), the sum of 9 skinfolds ($r = -0.32$), the sum of upper body skinfolds ($r = -0.34$), body fat percentage ($r = -0.32$), weekly kilometers ran ($r = 0.31$), longest training session before the 24-hour run ($r = 0.56$), and personal best marathon time ($r = -0.58$) were related to race performance. Stepwise multiple regression showed that both the longest training session before the 24-hour run ($p = 0.0013$) and the personal best marathon time ($p = 0.0015$) had the best correlation with race performance. Performance in these 24-hour runners may be predicted ($r^2 = 0.46$) by the following equation: Performance in a 24-hour run, km) = 234.7 + 0.481 (longest training session before the 24-hour run, km) – 0.594 (personal best marathon time, minutes). For practical applications, training variables such as volume and intensity were associated with performance but not anthropometric variables. To achieve maximum kilometers in a 24-hour run, recreational ultrarunners should have a personal best marathon time of ~3 hours 20 minutes and complete a long training run of ~60 km before the race, whereas anthropometric characteristics such as low body fat or low skinfold thicknesses showed no association with performance.

Key Words skinfold thickness, body fat, body composition, ultraendurance

Introduction

Running is a popular sports discipline, which can be performed over different distances (27,29). Different physiological, anthropometrical, and training characteristics seem to influence running performances, depending on the length and duration of the performance (1,28,30,31). Anthropometric characteristics such as body mass (3,18), body height (3,24,26), body mass index (11,13,25), body fat (11), the sum of total skinfold thickness (3), single skinfold thickness of the lower limb (2,3,22,23), the length of legs (21,35), and the circumferences of limbs (16,18,25,35) are known to be related to running performance. These anthropometric properties were differently related regarding running distances. Body height was associated with performance in running a 10-km race (3) and marathons (24), body mass was related to ultramarathon performances (18), and body mass index was related to both the marathon (11) and ultramarathon performances (13). Body fat was positively associated with marathon performance times (11). The sum of 7 skinfold thicknesses was correlated to marathon performance times (10) and the sum of skinfold thicknesses, the type and frequency of training and the number of years running were the best predictors of running performance over 10 km (3). A relationship between the thicknesses of selected skinfolds and running performance has been demonstrated in top class runners (2,23), where high correlations were found between the front thigh and medial calf skinfold and 10-km race times in male runners (2).

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Apart from anthropometry, volume and intensity in training seem to influence running performance in runners up to the marathon distance. In marathon finishers, the longest mileage covered per training session was the best predictor for a successful marathon performance (36). Runners training for >100 km·wk^{-1} had significantly faster race times over 10-90 km compared to athletes covering, <100 km (33) and elite runners with a higher training frequency, a higher weekly training volume, and a longer running experience had a better 10-km performance (3). A correlation exists between seasonal weekly duration of moderate continuous running for runners specializing in longer distances. Intensity in running is also of importance (12). Top class marathon runners trained for more total kilometers per week and at a higher velocity than runners at a lower level (6). Peak running velocity was highly related to 5-km run times for both male and female athletes (32). When training in marathoners was analyzed in detail, several parameters, such as the number of training sessions, total kilometers ran, mean kilometers per training session, longest mileage covered per training session, total training minutes, maximal kilometers run per week, mean kilometers per week, and mean kilometers per day, seem to have an effect on marathon performances (10,11,36).

Little is known about the association between both anthropometry and training and performance in ultrarunning, covering distances longer than the classic marathon distance of 42.195 km. There are data about the association of anthropometry and race performance in ultramarathon running (12,13,16–20). Probably, a thinner upper body with low circumferences of the upper arm is advantageous for ultrarunners of distances of >300 km (18) or even 1,200 km (16). Regarding the relationship between training and performance, there are little data about a potential association of training parameters and race performance in ultramarathoners. In 100-km ultramarathoners, training volume and personal best time in a marathon were related to race time (20). Previous race experience might be of importance, because in a recent study of male ultrarunners, a positive association of a personal best time in marathon running on performance in a 24-hour run was demonstrated, whereas anthropometry and training volume showed no relationship (17). In 100-km ultramarathoners, personal best time in a marathon, and training volume, were related to race time (20).

The aim of this study was to investigate which of the characteristics of anthropometry, training, and prerace experience was associated with race performance in a 24-hour ultrarun. We hypothesized finding an association between skinfold thicknesses and body fat, respectively, and performance in a 24-hour ultrarun and to establish an equation with both anthropometric and training variables to predict race performance. Such an equation would help future 24-hour ultramarathoners to prepare adequately for a 24-hour run to focus on anthropometry, such as low body fat, or training such as high volume, or high-intensity in running.

Methods

Experimental Approach to the Problem

The organizer of the '24-hour run' in Basel, Switzerland, contacted all participants of the race via a separate newsletter upon inscription to the race from 2008 to 2010, to increase the sample size. The '24-hour run' in Basel takes place every year in the middle of May. Runners from all over Europe start at noon to perform as many laps as possible on a flat course over 24 hours. Each lap of 1,141.86 m is counted by a personal lap counter for each runner.

Subjects

A total of 63 male runners participated in the investigation. The subjects were informed of the experimental risks and gave their informed written consent before the investigation. The study was approved by the Institutional Review Board for use of Human subjects. Table 1 shows their anthropometric characteristics and their prerace experience. The athletes had the opportunity to take food and beverages from an abundant buffet provided by the organizer and their own food from their own support crews. The support crews could also help

Table 1. Age, anthropometry, training, and prerace experience of the subjects ($n = 63$).*

Age (y)	46.9 (10.3)
Body mass (kg)	73.3 (7.6)
Body height (m)	1.78 (0.07)
Body mass index (kg·m^{-2})	23.1 (1.8)
Length of leg (cm)	87.0 (5.3)
Sum of 9 skinfolds (mm)	89.9 (31.1)
Sum of upper body skinfolds (mm)	70.9 (25.0)
Sum of lower body skinfolds (mm)	19.0 (8.8)
Body fat percentage (%)	16.1 (4.1)
Number of years as competitive runner (y)	13.8 (9.2)
Weekly kilometers ran (km)	85.7 (35.8)
Hours ran per week (h)	9.2 (5.3)
Average speed of the training sessions (km·h^{-1})	10.3 (1.5)
Longest training session before the 24-h run (km)	63.8 (33.6)
Number of finished marathons ($n = 61$)	27.5 (24.0)
Personal best time in a marathon (min) ($n = 61$)	198.3 (32.0)
Number of finished 100-km runs ($n = 43$)	9.3 (17.0)
Personal best time in a 100-km run (min) ($n = 43$)	634.4 (148.2)
Number of finished 24-h runs ($n = 38$)	6.9 (8.9)
Personal best performance in a 24-h run (km) ($n = 38$)	174.7 (40.1)

*Values are given as mean ± *SD*.

to change clothes and shoes. Table 2 shows the general weather conditions in the 3 years.

Procedures

In the 4 hours before the start of the race, body mass, body height, and the thickness of 9 skinfolds (pectoralis, axillar, biceps, triceps, subscapular, abdomen, suprailiac, thigh, and calf) were measured. With these data, body mass index and percent body fat were calculated. Body mass was measured using a commercial scale (Beurer BF 15, Beurer, Ulm, Germany) to the nearest 0.1 kg. Body height was measured using a stadiometer to the nearest 0.5 cm. The sum of the 7 upper body skinfolds (pectoralis, axillar, biceps, triceps, subscapular, abdomen, suprailiac) and the 2 lower body skinfolds (thigh and calf) were determined. Skinfold data were obtained using a skinfold calliper (GPM-Hautfaltenmessgerät, Siber & Hegner, Zurich, Switzerland) and recorded to the nearest 0.2 mm. One trained investigator took all the measurements, because intertester variability is a major source of error in skinfold measurements. All skinfold thicknesses were determined on the right side of the body for all the athletes. The skinfold measurements were taken 3 times, and the mean was then used for the analyses. The skinfold measurements were standardized to ensure reliability, and readings were performed 4 seconds after applying the calliper, according to Becque et al. (5). An intratester reliability check was conducted on 27 male runners before testing. No significant difference between the 2 trials for the sum of skinfolds was observed ($p > 0.05$). The intraclass correlation was high at $r = 0.95$. The same investigator was also compared to another trained investigator to determine objectivity. No significant difference existed between testers ($r = 0.97$; $p > 0.05$). Percent body fat was calculated using the following anthropometric formula according to Ball et al. (5): Percent body fat = $0.465 + 0.180(\Sigma 7SF) - 0.0002406(\Sigma 7SF)^2 + 0.0661(\text{age})$, where Σ7SF = sum of skinfold thickness of pectoralis, axillar, triceps, subscapular, abdomen, suprailiac, and thigh. This formula was evaluated using 160 men aged 18–62 years and crossvalidated with dual energy x-ray absorptiometry

Table 2. General weather conditions in 3 years.

	2008	2009	2010
Temperature at the start (°C)	21	23	17
Lowest temperature in the night (°C)	10	11	10
Temperature at the finish (°C)	31	29	18
Highest barometric pressure (hPa)	1,019.8	1,031.1	1,009.1
Lowest barometric pressure (hPa)	1,018.6	1,019.7	1,008.0
Lowest relative humidity (%)	27	21	72
Highest relative humidity (%)	86	90	96

Table 3. Relationship of selected variables of age, anthropometry, training, and prerace experience to race performance using bivariate analysis ($n = 63$).*

	R
Age	0.04
Body mass	−0.25†
Body height	−0.15
Body mass index	−0.18
Length of leg	−0.20
Sum of 9 skinfolds	−0.32‡
Sum of upper body skinfolds	−0.34‡
Sum of lower body skinfolds	−0.17
Body fat percentage	−0.32‡
Number of years participating in running	0.04
Weekly kilometers ran	0.31†
Hours ran per week	0.20
Average speed of the training sessions	0.24
Longest training session before the 24-h run	0.56‡
Personal best time in a marathon	−0.58‡

*R = Pearson correlation coefficients.
†$p < 0.05$.
‡$p < 0.01$.

Table 4. Stepwise multiple regression with the race performance as the dependent variable ($n = 61$).*†

	β	*SE*	*p*
Body mass	−0.219	0.622	0.726
Sum of 9 skinfolds	−0.269	0.823	0.744
Sum of upper body skinfolds	−0.218	0.852	0.799
Body fat percentage	2.897	5.929	0.627
Weekly kilometers ran	−0.025	0.142	0.857
Longest training session before the 24-h run	0.491	0.144	0.0013
Personal best time in a marathon	−0.560	0.167	0.0015

*β = regression coefficient; *SE* = standard error of the regression coefficient.
†Coefficient of determination (r^2) of the model was 47%. Personal best time in a marathon and the distance of the longest training session were the best-correlated variables with the race performance.

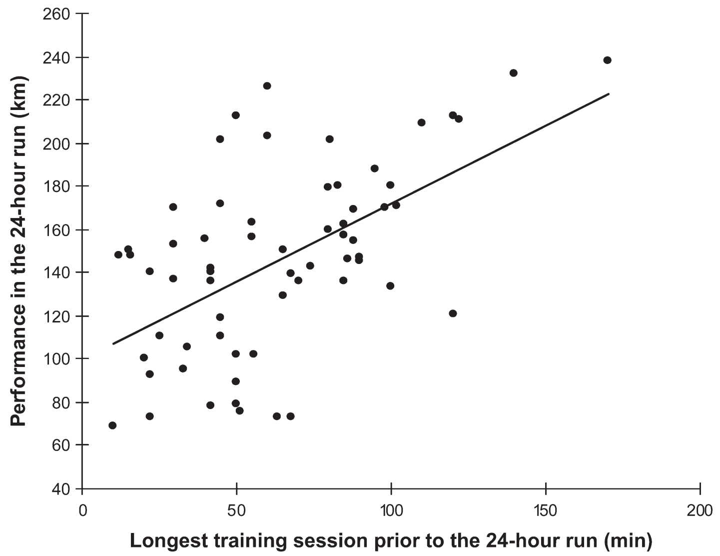

Figure 1. The longest training session before the 24-hour run was significantly and positively related to race performance ($n = 63$) ($r = -0.56$, $p < 0.0001$).

(DXA). The mean differences between DXA percent body fat and calculated percent body fat ranged from 3.0 to 3.2%. Significant ($p < 0.01$) and high ($r > 0.90$) correlations existed between the anthropometric prediction equations and DXA.

Upon inclusion in the study until the start of the race, the athletes were asked to maintain a comprehensive training diary, consisting of training sessions showing distance and duration in the preparation for the race. The training record consisted of the number of weekly training units showing duration, kilometers and pace, weekly kilometers ran, and weekly hours ran. The athletes recorded their speed in running during training in minutes per kilometers. Furthermore, they reported on the number of years that they had actively participated in marathon and ultramarathon competitions, and the number of marathons, 100-km runs, and 24-hour runs that were successfully completed and their best performances achieved in these disciplines. Regarding marathon performances, the athletes reported the year of their personal best marathon time and the year of the last marathon completed before the actual race.

Statistical Analyses

Data are presented as mean and *SD*. The number of years between a personal best marathon time and the 24-hour run was compared with the number of years between the last marathon and the 24-hour run using paired *t*-test. The time of the personal best marathon and the last marathon completed before the 24-hour run was also compared using the paired *t*-test. The coefficient of variation of performance (CV% = 100 × *SD*/mean) was calculated. The relationship between race performance as the dependent variable and selected variables of prerace experience, training, and anthropometry as the independent variables were analyzed using bivariate Pearson correlation analysis. Stepwise multiple regression analysis was then used to determine the best variables correlating to the race performance. A power calculation was performed according to Gatsonis and Sampson (8).

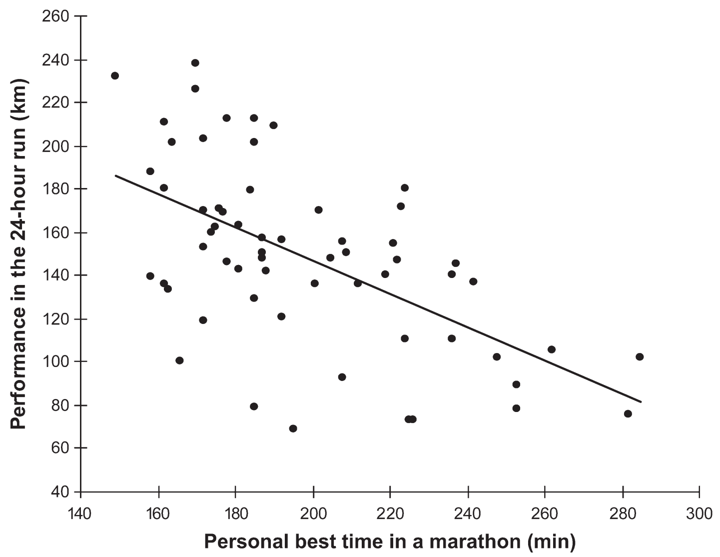

Figure 2. The personal best time in a marathon was significantly and negatively related to race performance ($n = 61$) ($r = -0.58$, $p < 0.0001$).

TABLE 5. Personal best times of the subjects (mean and *SD*) and expression of their performance as a percentage of the male World record.

	World record (y)	Personal best time of the subjects	Expressed as % of the World record
Marathon race time	2 h 04 min (2008)	3 h 18 min (32 min)	~160
100-km Race time	6 h 33 min (2000)	10 h 34 min (2 h 18 min)	~160
Performance in 24-h run	290.2 km (1998)	174.7 (40.1) km	~165

To achieve a power of 80% (2-sided type I error of 5%) to detect a minimal association between race time and anthropometric characteristics of 20% (i.e., coefficient of determination $r^2 = 0.2$) a sample of 40 participants was required. An alpha level of 0.05 was used to indicate significance.

RESULTS

The 63 athletes achieved a mean distance of 146.1 (43.1) km (CV = 29.5%). The athletes achieved their personal best marathon time 7.4 (7.6) years before the 24-hour run and completed the last marathon 1.3 (2.0) years before the competition ($p < 0.0001$). The personal best marathon time, with 197 (31) minutes, was faster compared to the time of the last marathon completed before the 24-hour run, with 221 (51) minutes ($p < 0.001$). Thirty-eight ultrarunners had already completed at least 1 24-hour run. Their personal best performance of 174 (40) km was better compared to the actual performance of 146 (43) km ($p < 0.001$).

In the bivariate analysis (Table 3), body mass ($r = -0.25$), the sum of 9 skinfolds ($r = -0.32$), the sum of upper body skinfolds ($r = -0.34$), body fat percentage ($r = -0.32$), weekly kilometers ran ($r = 0.31$), longest training session before the 24-hour run ($r = 0.56$), and personal best marathon time ($r = -0.58$) were related to race performance. Stepwise multiple regression analysis (Table 4) showed that the longest training session before the 24-hour run (Figure 1), and the personal best marathon time (Figure 2), had the best correlation to race performance. Performance in these 24-hour runners may be predicted ($r^2 = 0.46$) by the following equation: performance in a 24-hour run (km) = 234.7 + 0.481 (longest training session before the 24-hour run, km) − 0.594 (personal best marathon time, minutes).

DISCUSSION

The aim of this study was to investigate which of the characteristics of anthropometry, training, and prerace experience was associated with race performance in a 24-hour ultrarun.

We hypothesized finding an association between skinfold thicknesses and body fat, respectively, with performance; however, we found an association between both the longest training session and the personal best marathon time and total kilometers ran. Although we found, in the bivariate analysis (Table 3), associations between the variables of anthropometry, such as body fat and skinfold thicknesses, both the longest training session and the personal best time in a marathon showed a higher correlation with kilometers ran compared to the anthropometric characteristics (Table 4).

Considering these findings, we must assume that training variables are more important than anthropometric variables regarding race performance in a 24-hour ultrarun. There are several studies of runners up to the marathon distance, which show that increased volume and intensity in training is of importance for running performance. Top class marathoners train for more total kilometers per week and at a higher velocity, compared to high-level runners (6). Christensen and Ruhling (7) concluded that improved performance in marathon runners was associated with higher aerobic capacity and years of training, rather than with body dimensions. Scrimgeour et al. (33) showed that runners training for >100 $km \cdot wk^{-1}$ had significantly faster running times in events of between 10 and 90 km, compared to runners with less training.

Regarding the relationship between training variables and race time, neither volume nor intensity in training was associated with race time (Table 3). In the bivariate analysis, both the longest training session and the personal best time in a marathon showed the highest correlation coefficients. Also, when we corrected with the covariates in the regression model (Table 4), both the longest training session and the personal best time in a marathon remained highly significantly related to race performance. This confirms previously reported findings in a smaller sample of ultrarunners during a 24-hour run, where the personal best marathon time was significantly and positively correlated to the achieved distance during the run (17). Furthermore, successful finishers in a multistage ultraendurance run over 1,200 km, with 17 stages, had a significantly faster personal best marathon time compared to nonfinishers (19). In both studies, however, anthropometric variables showed no association with ultraendurance performances. An additional finding is that the longest training session was related to race performance. In a study of Ironman triathletes, the longest training ride was also related to race performance (9). Previous best performances in an Olympic distance triathlon (1.5/40/10), coupled with weekly cycling distances and longest training ride, could partially predict overall performance ($r^2 = 0.57$).

Although anthropometric characteristics such as skinfold thicknesses and body fat percentage showed an association with race time in the bivariate analysis, training characteristics, such as the longest training session before the race, became more important in the multivariate analysis when controlled for all covariates. This is also expressed in the regression model with both the longest training session before the race and the personal best time in a marathon as predictor variables for race performance. We must be aware that, obviously, in these ultramarathoners training is more important compared to 'classic' anthropometric characteristics, such as body mass, body height, and body mass index, which seem to be more relevant in distances up to the marathon distance.

In a 24-hour run, the runners do not have to finish a defined distance within a time limit, which is generally the opposite of what is expected in an endurance performance, but instead have to cover the greatest possible distance within 24 hours. Therefore, the athletes can run more slowly, or as fast as possible, and take breaks or go to sleep when they want. In case an athlete suffers from an overuse injury or has a medical problem, such as dehydration or a digestive problem, he can stop, solve the problem, and continue the race. This may explain the large CV of 29.2% in race performance. However, the large CV of 29.5% in race performance and the rather weak performance of ~150 km, varying from 73 to 231 km in 24 hours, compared to the 199 km in the study of Kao et al. (14) with distances between 127 and 261 km might also be an indicator of motivational problems (19). Table 5 shows the World records for the marathon, 100-km, and 24-hour run and the absolute performances of our subjects, and expressed as a percentage of the World records. This shows that our recreational subjects are ~60% slower for the marathon, 100-km, and 24-hour run compared to the corresponding World records.

The design of a cross-sectional study is limited regarding the influence and effects of anthropometry and both volume and intensity during training on race performance, because only an intervention trial can answer this question. Another limitation is the lack of fitness evaluation of these athletes, because we focused this investigation primarily on the relationship of anthropometry, prerace experience and training with kilometers ran. Other aspects such as nutrition and the influence of the environment were not considered. When we compare the 199 km of the 23 runners in the study of Kao et al. (14) and the ~150 km of our 63 runners, the ambient temperature might be of importance. Although our runners had temperatures between 20 and 30°C, the runners of Kao et al. (14) faced temperatures between 11 and 15°C. Unfortunately, we have no data about energy deficit (15) or disorders in fluid or electrolyte metabolism (34), which might also limit an ultraendurance performance. Dehydration with a decrease in body mass might have a considerable impact on running performance during 24 hours (14), although body weight loss may not affect performance in ultraendurance running (37). The hydration status was not determined in all subjects prerace. Altered hydration status might affect skinfold thickness, and race performance.

Practical Applications

We found, in these recreational 24-hour ultrarunners, that both the longest training session before the race and the personal best time in a marathon were related to race performance, whereas anthropometric characteristics such as low body fat or low skinfold thicknesses were not related to race performance. For practical applications, athletes intending to achieve maximum kilometers in a 24-hour run should focus on high training volume and fast marathon running, rather than lowering body fat and reducing skinfold thicknesses by diet.

To achieve maximum kilometers in a 24-hour run, recreational ultrarunners should have a personal best marathon time of ~3 hours 20 minutes and complete a long training run of ~60 kilometers before the race, whereas anthropometric characteristics such as low body fat or low skinfold thicknesses showed no association with performance. A race performance of ~150 km in a 24-hour run might then be realistic.

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