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Comparison of Training and Anthropometric Characteristics between Recreational Male Half-Marathoners and Marathoners

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Abstract

Participation in endurance running such as half-marathon (21-km) and marathon (42-km) has increased over the last decades. We compared 147 recreational male half-marathoners and 126 recreational male marathoners to investigate similarities or differences in their anthropometric and training characteristics. The half-marathoners were heavier ($P < 0.05$), had longer legs ($P < 0.001$), thicker upper arms ($P < 0.05$), a thicker thigh ($P < 0.01$), a higher sum of skinfold thicknesses ($P < 0.01$), a higher body fat percentage ($P < 0.05$) and a higher skeletal muscle mass ($P < 0.05$) than the marathoners. They had fewer years of experience ($P < 0.05$), completed fewer weekly training kilometers ($P < 0.001$), and fewer weekly running hours ($P < 0.01$) compared to the marathoners. For half-marathoners, body mass index ($P = 0.011$), percent body fat ($P = 0.036$) and speed in running during training ($P < 0.0001$) were related to race time ($r^2 = 0.47$). For marathoners, percent body fat ($P = 0.001$) and speed in running during training ($P < 0.0001$) were associated to race time ($r^2 = 0.47$). When body mass index was excluded for the half-marathoners in the multi-variate analysis, r^2 decreased to 0.45, therefore body mass index explained only 2% of the variance of half-marathon performance. Percent body fat was significantly and negatively related to running speed during training in both groups. To summarize, half-marathoners showed differences in both anthropometry and training characteristics compared to marathoners that could be related to their lower training volume, most probably due to the shorter race distance they intended to compete. Both groups of athletes seemed to profit from low body fat and a high running speed during training for fast race times.

Key Words: skinfold thickness, body fat, running, training

Introduction

Marathon running enjoys a high popularity (4, 21) where the majority of marathoners and half-marathoners are recreational runners (7). For the ‘New York City Marathon’, recreational marathoners have to register at least one year in advance to take part in the ‘ultimate ride’ among 45,000 other marathoners* (21). Although marathon running is of high popularity, the participation in half-marathon running is higher compared to marathon (www.runningusa.org/statistics). In the United States, a total of 467,000

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*Baruch College, 2011. http://www.baruch.cuny.edu/nycdata/chapter14_files/sheet032.htm persons finished a marathon in 2009. In contrast, in the same year, a total of 1,113,000 persons finished a half-marathon. In other terms, ~58% more persons completed a half-marathon than a marathon. In comparison, in 1990, a total of 224,000 persons completed a marathon and 303,000 a half-marathon where the difference was ~26%. In other words, between 1990 and 2009, the finisher rate increased by ~73% in half-marathons, but only by ~52% in marathons. Therefore, ~21% more persons finished a half-marathon compared to a marathon in the last ~20 years in the United States.

Endurance performance depends on several predictor variables such as psychological aspects (25), genetic and demographic characteristics (26), physiological parameters (28, 34), age (21), gender (28), training (14, 18, 33), previous experience (13) and anthropometric characteristics (12, 30). Regarding training, Karp (14) described training characteristics of 94 marathoners. Marathon performance correlated to 5 km, 10 km and half-marathon performance, years of training, both mean and peak of weekly running distance and the number of weekly training runs. Hagan *et al*. (12) reported that marathon performance times were significantly inversely related to total workout days, average kilometers per workout and total kilometers. Yeung *et al*. (35) described that a long range covered in training sessions was a good predictor to complete a marathon successfully. In addition, age should not be neglected in considering running race times (21, 22). The marathon community over the age of 40 years has grown significantly for the past 30 years (4, 21). Also, age-related losses in endurance performances have been found in athletes over the age of 50 years (21, 22). Peak marathon performance was generally achieved when runners were 25 to 35 years old (32). On top of age, gender seemed to influence running performance as well (21). Men were faster in marathon running than women (6, 28). Regarding origin and ethnicity of elite marathoners, Onywera *et al*. described Kenyan endurance runners and their connection to geographic distributions, their way to school and ethnicity (26, 27). Compared to national athletes and non-athletes, international top class runners had longer ways to school, went there on a daily basis and came from a different province (26, 27). Considering anthropometric characteristics, taller runners seemed to run slower than smaller runners. Moreover, a relationship between running performance times and skinfold thickness was mentioned. Hagan *et al*. (12) found a correlation between marathon performance times and both the sum of seven skinfolds and body weight. However, in elite male runners, a high correlation of both the front thigh and the medial calf skinfold thicknesses with 1,500 m and 10,000 m running times has been described (1). Overall, a low body mass index and thin skinfold thicknesses seemed to be important variables for fast performance times. Skinfold thicknesses at the lower limbs can serve as predictor for race performance (1, 20). A low body mass index may result from both high training volume and genetic predisposition. According to Legaz and Eston (20), a high training volume decreased the sum of six skinfolds and the skinfold thicknesses of the abdominal, front thigh and medial calf sites in elite runners.

Regarding half-marathoners, it has been shown that anthropometric characteristics such as body mass index were related to performance times (16, 29). In addition to body mass index, previous studies focused also on skinfold thicknesses (16, 17, 29). The upper body skinfold thicknesses remained significant for half-marathon race time after multi-variate analysis for recreational female runners (17). Suprailiacal and medial calf skinfold thicknesses were related to half-marathon race times (29). In relation to training characteristics, a high running speed in training sessions seems to correlate to fast race times for both recreational female and recreational male half-marathoners (16, 17, 29). Rüst *et al*. (29) recently described that training-related weekly kilometers, training sessions and running distance, running distance in one training session and running speed while training were related to race performance times in recreational male half-marathoners.

Training characteristics, anthropometry and their association to race performance have been investigated in previous studies for marathoners (1, 12, 20, 35). However, there is little data relating to the relationship between predictor variables and race performance in half-marathoners. In addition, most of the studies have focused on elite runners but not on recreational runners. Since the rate of finishers in half-marathons seems to increase faster than the rate of finishers in marathons (www.runningusa.org/statistics), we intended to investigate similarities and differences in training characteristics and anthropometry between half-marathoners and marathoners. Most probably, future marathoners start first with a half-marathon to gain experience before they start in a marathon. The knowledge of the relevant variables affecting marathon performance is important for novice marathoners to plan the preparations of the first marathon.

The aims of the study were [1] to compare anthropometry and training characteristics between recreational male half-marathoners and recreational male marathoners and [2] to find the best predictor variables for both marathon and half-marathon performance. We hypothesized [i] a difference in training and body composition particularly for skinfold thicknesses and body mass index between marathoners and half-marathoners and [ii] that both anthropometric and training variables would be related to marathon and half-marathon performance time in non-elite runners. Most presumably, differences do exist between these two groups and these results could help half-marathoners to improve their training habits to start in their first marathon. Potential findings in differences in predictor variables between half-marathoners and marathoners might help future marathoners to prepare more adequately for their first marathon.

Materials and Methods

Subjects and Races

All male marathoners and half-marathoners participating in the 'Basel Marathon' in Basel, Switzerland, were informed about the planned investigation *via* an electronic newsletter sent by the organizer three months before the start of the race, plus separate information shown on the race website. In the 'Basel Marathon', athletes can run either a half-marathon or a marathon. In order to increase the sample size, athletes were recruited in two consecutive years, from 2010 to 2011. In the marathon, the athletes had to run two laps on asphalt with a total altitude of 200 m. In the half-marathon, the runners had to complete one lap with a total altitude of 100 m. No athlete was included twice and no athlete competed in both races. The study was approved by the Institutional Review Board for use of Human Subjects of the Canton of St. Gallen, Switzerland. The athletes were informed of the experimental procedures and gave their informed written consent. A total of 126 marathoners and 147 half-marathoners participated as study subjects.

Measurements and Calculations

Upon inscription to the study three months before the start of the 'Basel Marathon', the subjects were asked to record their training sessions showing duration in minutes and distance in kilometers until the start of the race. The investigators provided an electronic file where the subjects could insert each training unit with distance (km), duration (min) and running speed (km/h). The investigators calculated the mean weekly hours, the mean weekly kilometers and the mean speed per discipline during training in the pre-race preparation for three months. The participants were also asked for their number of completed half-marathons and marathons including their personal best time where the personal best time was defined as the fastest time ever achieved in a half-marathon and marathon independent upon the topography of the course and the environmental conditions.

The afternoon the day before the start of the races, anthropometric characteristics such as body mass, body height, the circumferences of the limbs, the length of the leg and the thicknesses of skinfolds at eight sites (*i.e.* pectoralis, axillar, triceps, subscapular, abdomen, suprailiacal, front thigh and medial calf) were measured. The circumferences of the limbs as well as all skinfold thicknesses were measured on the right side of the body. With this data, body mass index, percent body fat and skeletal muscle mass, using anthropometric methods, were estimated. Body mass was measured using a commercial scale (Beurer BF 15, Beurer, Ulm, Germany) to the nearest 0.1 kg. Body height was determined using a stadiometer (Tanita HR 001 Portable Height Measure, Tanita Europe, Amsterdam, Netherlands) to the nearest 1.0 cm. The length of the leg and the circumferences of the limbs were measured using a non-elastic tape measure (KaWe CE, Kirchner und Welhelm, Germany) to the nearest 0.1 cm. The circumference of the upper arm was measured ad mid-arm, the circumference of the thigh was taken at mid-thigh and the circumference of the calf was measured at mid-calf. All the skinfold data were obtained using a skinfold caliper (GPM-Hautfaltenmessgerät, Siber & Hegner, Zurich, Switzerland) and recorded to the nearest 0.2 mm. The skinfold caliper measures with a pressure of 0.1 Mpa ± 5% over the whole measuring range. The skinfold measurements were taken once for all eight skinfold sites, and then the procedure was repeated twice more by the same investigator; the mean of the three measurements was then used for the analyses. The timing of the taking of the skinfold measurements was standardized to ensure reliability. According to Becque *et al.* (3), readings were performed 4 sec after applying the caliper. One trained investigator took all the skinfold measurements, as inter-tester variability is a major source of error in skinfold measurements. Intra- and inter-rater agreement was assessed from 27 male runners prior to an ultra-marathon, based on measurements taken by two experienced primary care physicians (15). Intraclass correlation (ICC) within the two raters was excellent for all anatomical measurement sites and for various summary measurements of skinfold thicknesses (ICC > 0.9). Agreement tended to be higher within than between raters, but still reached excellent reliability (ICC > 0.9) for the summary measurements of skinfold thicknesses. Percent body fat was estimated using the anthropometric formula according to Ball *et al.* (2) for males with percent body fat = $0.465 + 0.180 \times (\Sigma 7SF) - 0.0002406 \times (\Sigma 7SF)^2 + 0.0661 \times (\text{age})$, where $\Sigma 7SF$ is the sum of seven skinfold thicknesses at pectoralis, axillar, triceps, sub-scapular, abdomen, suprailiacal and thigh site in mm; age is in years. Skeletal muscle mass (SMM) was estimated using the formula of Lee *et al.* (19) with SMM = Ht × (0.00744 × CAG^2 + 0.00088 × CTG^2 + 0.00441 × CCG^2) + 2.4 × sex – 0.048 × age + race + 7.8 where Ht = body height, CAG = skinfold-corrected upper arm girth, CTG = skinfold-corrected thigh girth, CCG = skinfold-corrected calf girth; sex = 1 for male; age is in years; race = 0 for white men and 1 for black men.

Statistical Analysis

Data were analyzed using SPSS software version 15 (SPSS Inc., Chicago, IL, USA). Data were checked for distribution of normality and are presented as means ± standard deviation (SD). The coefficient of variation (CV) of performance (CV% = 100 × SD/mean) was calculated. The CV describes the magnitude sample values and the variation within them. Data for the half-marathoners and the marathoners were compared using unpaired *t*-test. To investigate a potential association between anthropometric and training characteristics with performance, in a first step, the relationship between race time as the dependent variable and the variables of age, anthropometry, training and previous experience was investigated using bi-variate Pearson correlation analysis. In order to reduce the variables for the multi-variate analysis, Bonferroni correction was applied ($P < 0.0017$ for 29 variables). In a second step, all significant variables after bi-variate analysis entered the multiple linear regression analysis (stepwise, forward selection, *P* of F for inclusion < 0.05, *P* of F for exclusion > 0.1). Multicollinearity between the predictor variables was excluded with $r > 0.9$. A power calculation was performed according to Gatsonis and Sampson (11). To achieve a power of 80% (two-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 for all statistical tests.

Results

A total of 144 marathoners applied as study participants and recorded their training, 126 marathoners (87.5%) appeared for the pre-race measurements and they all completed the race. For the half-marathoners, a total of 179 volunteers recorded their training, 147 half-marathoners (82.2%) were measured pre-race and they all finished the race. The 126 marathoners completed their race within 232 ± 32 min (CV = 13.1%), running at a mean speed of 11.1 ± 1.4 km/h. The 147 half-marathoners finished within 106 ± 17 min (CV = 16%); their running of speed of 12.2 ± 1.9 km/h was significantly faster ($P < 0.0001$) compared to the marathoners. Expressed in percent of the course record of 2 h 38 min set by Andreas Schur in 2010, the marathoners finished within 146 ± 19%. The half-marathoners finished within 157 ± 21% of the course record of 1 h 8 min set by Berhane Ogubit in 2011. Expressed in percent of the course record, the marathoners finished their race significantly faster compared to the half-marathoners ($P = 0.003$).

The half-marathoners were heavier, had longer legs, a thicker upper arm and a thicker thigh, a thicker skinfold thickness at pectoral, abdominal, suprailiacal, and thigh site compared to the marathoners (Table 1). In addition, they had a higher sum of skinfold thicknesses, a higher body fat percentage and a higher skeletal muscle mass compared to the marathoners. Considering training, the half-marathoners were running for fewer years, completed less weekly running kilometers, they were running fewer hours per week, completed fewer training sessions, achieved fewer kilometers per training session, and invested fewer minutes per training session compared to the marathoners. Regarding previous experience, no difference existed for the number of completed half-marathons between half-marathoners and marathoners ($P > 0.05$). Considering the number of previous completed marathons, the marathoners had finished significantly more marathons compared to the half-marathoners ($P < 0.01$). The personal best time in both a half-marathon and a marathon was not different between half-marathoners and marathoners ($P > 0.05$).

Table 2 shows the bi-variate analyses where variables with a $P < 0.0017$ were included in the multi-variate analysis. For the half-marathoners, body mass index, percent body fat and speed in running during training were related to race time (Table 3). Race time (min) for half-marathoners might be partially predicted ($r^2 = 0.47$) by the equation: Race time (min) = 115.7 + 2.052 × body mass index (kg/m^2) – 5.346 × speed in running during training (km/h). In the marathoners, percent body fat and speed in running during training were associated with race time (Table 4). For marathoners, race time (min) might be partially predicted ($r^2 = 0.43$) by the equation: Race time (min) = 326.3 + 2.394 × percent body fat (%) – 12.06 × speed in running during training (km/h). For both half-marathoners (Fig. 1) and marathoners (Fig. 2), the speed in running during training was significantly and negatively related to percent body fat.

Because for both half-marathoners and marathoners percent body fat and running speed during training units were related to race but body mass

Table 1. Comparison of anthropometry and training between half-marathoners and marathoners

	Half-marathoners (n = 147)	Marathoners (n = 126)	Significance
Age (years)	40.2 ± 10.1	42.8 ± 10.8	
Body mass (kg)	75.8 ± 8.6	73.9 ± 8.1	*
Body height (m)	1.79 ± 0.06	1.78 ± 0.06	
Body mass index (kg/m^2)	23.3 ± 2.2	23.7 ± 2.7	
Length of leg (cm)	87.7 ± 4.8	85.8 ± 4.2	***
Circumference of upper arm (cm)	29.7 ± 2.0	29.2 ± 1.9	*
Circumference of thigh (cm)	55.9 ± 3.2	55.0 ± 2.6	**
Circumference of calf (cm)	38.2 ± 2.5	37.9 ± 2.3	
Skinfold pectoral (mm)	9.4 ± 4.2	8.2 ± 3.0	*
Skinfold axilla (mm)	10.6 ± 4.3	9.7 ± 2.9	
Skinfold triceps (mm)	8.6 ± 2.8	7.9 ± 2.6	
Skinfold subscapular (mm)	11.3 ± 4.3	10.5 ± 4.0	
Skinfold abdominal (mm)	18.8 ± 9.1	15.4 ± 6.3	**
Skinfold suprailiacal (mm)	20.8 ± 9.4	18.4 ± 7.1	*
Skinfold thigh (mm)	13.7 ± 6.1	12.1 ± 4.9	*
Skinfold calf (mm)	6.7 ± 2.7	6.2 ± 2.4	
Sum of skinfolds (mm)	99.9 ± 35.6	88.3 ± 26.2	**
Percent body fat (%)	17.5 ± 4.6	16.3 ± 3.6	*
Skeletal muscle mass (kg)	39.1 ± 3.1	38.3 ± 3.3	*
Years as active runner (y)	7.9 ± 8.0	10.5 ± 9.4	*
Weekly running kilometers (km)	33.7 ± 20.5	44.7 ± 24.7	***
Minimal weekly running distance (km)	16.2 ± 13.5	22.8 ± 20.8	**
Maximal weekly running distance (km)	45.2 ± 29.1	63.3 ± 32.7	***
Weekly running hours (h)	3.9 ± 2.0	4.8 ± 2.4	***
Number of training units (n)	3.1 ± 1.3	3.7 ± 1.6	**
Distance per training unit (km)	11.3 ± 3.2	14.2 ± 6.6	***
Duration per training unit (min)	63.0 ± 16.5	72.5 ± 20.5	***
Speed in running training (km/h)	10.8 ± 1.5	11.1 ± 1.4	
Number of completed half-marathons (n)	6 ± 7 (n = 108)	7 ± 13 (103)	
Number of completed marathons (n)	4 ± 3 (50)	12 ± 21 (n = 92)	**
Personal best time half-marathon (min)	102 ± 17	99 ± 12	
Personal best time marathon (min)	224 ± 36	216 ± 32	

Results are presented as means ± SD. *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

index was also associated with race time for half-marathoners, we performed a second multi-variate analysis for half-marathoners with the exclusion of body mass index. The coefficient of determination of the model decreased from $r^2 = 0.47$ to $r^2 = 0.45$. Therefore, body mass index explained 2% of the variance of performance in half-marathoners.

Discussion

The present study showed differences in both anthropometry and training characteristics between recreational male half-marathoners and recreational male marathoners. The marathoners were lighter, had shorter legs, smaller circumferences of the upper arms and thighs compared to the half-marathon runners. Similar results can be found in Arrese and Ostáriz (1) who investigated 184 elite runners of several running distances (*i.e.* 100 m, 400 m, 800 m, 1,500 m, 3,000 m, 10,000 m and marathon, respectively). Long-distance runners were older, lighter and shorter than middle- and speed-distance runners. According to the thickness of skinfolds, the present marathoners had a lower sum of six skinfolds than the half-marathoners. However, the short-distance runners (100 - 1,500 m and 10,000 m, respectively) of Arrese and Ostáriz (1) had a higher sum of six skinfolds compared to the marathoners. All of their marathoners

Table 2. Association of anthropometric and training characteristics with race time for both half-marathoners and marathoners

	Half-marathoners (n = 147)		Marathoners (n = 126)	
	r	*P*	*r*	*P*
Age	0.27	0.001	0.23	0.009
Body mass	0.27	0.0009	0.27	0.007
Body height	-0.17	0.04	-0.01	0.9
Body mass index	0.46	< 0.0001	0.27	0.002
Length of leg	-0.21	0.01	-0.03	0.8
Circumference of upper arm	0.37	< 0.0001	0.15	0.09
Circumference of thigh	0.15	0.07	0.22	0.01
Circumference of calf	0.14	0.08	0.18	0.04
Skinfold pectoral	0.43	< 0.0001	0.35	< 0.0001
Skinfold axilla	0.41	< 0.0001	0.40	< 0.0001
Skinfold triceps	0.35	< 0.0001	0.23	0.01
Skinfold subscapular	0.39	< 0.0001	0.25	0.004
Skinfold abdominal	0.44	< 0.0001	0.37	< 0.0001
Skinfold suprailiacal	0.35	< 0.0001	0.31	0.0004
Skinfold thigh	0.29	0.0004	0.34	0.0001
Skinfold calf	0.48	< 0.0001	0.41	< 0.0001
Sum of skinfolds	0.47	< 0.0001	0.42	< 0.0001
Percent body fat	0.49	< 0.0001	0.44	< 0.0001
Skeletal muscle mass	-0.07	0.4	-0.02	0.8
Years as active runner	-0.02	0.8	-0.08	0.3
Weekly running kilometers	-0.48	< 0.0001	-0.30	0.0007
Minimal weekly running distance	-0.36	< 0.0001	-0.22	0.01
Maximal weekly running distance	-0.46	< 0.0001	-0.32	0.0003
Weekly running hours	-0.30	0.0002	-0.20	0.03
Number of training units	-0.42	< 0.0001	-0.33	0.0002
Distance per training unit	-0.32	< 0.0001	-0.17	0.06
Duration per training unit	-0.2	0.01	0.02	0.8
Speed in running training	-0.58	< 0.0001	-0.61	< 0.0001
Number of completed races	-0.13	0.1	0.09	0.4
Personal best time	0.85	< 0.0001	0.67	< 0.0001

Variables with *P*-values of < 0.0017 are inserted in the multi-variate analysis (n = 29 variables).

(n = 17) showed that the sum of six skinfolds was lower compared to all other groups like we detected. Additionally, we found a thinner skinfold thickness at pectoral, abdominal, suprailiacal and thigh site in the present marathoners compared to the half-marathoners. Obviously, marathoners represent thinner skinfolds than short-distance runners. Potential reasons for these findings may be a higher training volume that catabolizes fat reduction (20), individual diets or genetic disposition.

The present half-marathoners were running for fewer years, completed less weekly running kilometers, ran fewer hours per week, completed less training sessions, achieved fewer kilometers per training session and invested fewer minutes per training session compared to the marathoners. Supporting arguments for these findings might be that recreational runners may start their running career with a half-marathon distance before they start to run a whole marathon. This assumption is also backed up by the lower number of completed marathons in the half-marathoners.

Regarding predictor variables of performance for anthropometry, only percent body fat was related to race time for both the half-marathoners and the marathoners. Also Arrese and Ostáriz (1) described 184 elite runners and their relationship between skinfold thickness and running performance in different distances but they did not focus on percent body fat. Like in our investigation, the marathon

Table 3. Associations between significant characteristics after bivariate analysis and race time for the half-marathoners using multiple linear regression (n = 147)

Model 1	β	t	P
Body mass	-0.30	-1.48	0.14
Body mass index	1.94	2.48	0.01
Circumference of upper arm	0.01	0.16	0.87
Percent body fat	0.63	2.12	0.03
Weekly running kilometers	-0.16	-1.57	0.11
Minimal weekly running distance	-0.13	-1.07	0.28
Maximal weekly running distance	0.003	0.07	0.96
Weekly running hours	0.14	1.54	0.12
Number of training units	-1.84	-1.46	0.14
Distance per training unit	-0.32	-0.85	0.39
Speed in running training	-3.7	-4.43	< 0.0001
Model 2	β	t	P
Body mass	0.004	0.03	0.97
Circumference of upper arm	0.49	0.77	0.44
Percent body fat	0.79	2.67	0.008
Weekly running kilometers	-0.15	-1.49	0.13
Minimal weekly running distance	-0.11	-0.96	0.34
Maximal weekly running distance	-0.005	0.07	0.94
Weekly running hours	1.08	1.17	0.24
Number of training units	-1.39	-1.09	0.27
Distance per training unit	-0.31	-0.83	0.40
Speed in running training	-4.13	-4.95	< 0.0001

r^2 = 0.510, adjusted r^2 = 0.47, Standard error of estimate = 12.6, $F_{(11)}$ = 12.76, $P < 0.0001$. Body mass index, percent body fat and running speed during training were related to half-marathon race time (Model 1). When body mass index was eliminated for a further multi-variate model (Model 2), r^2 decreased to 0.49 and adjusted r^2 to 0.45. Standard error of estimate = 12.8, $F_{(11)}$ = 12.94, $P < 0.0001$.

Table 4. Associations between significant characteristics after bivariate analysis and race time for the marathoners using multiple linear regression (n = 126)

	β	t	P
Percent body fat	0.242	3.270	0.001
Weekly running kilometers	-0.040	-0.354	0.724
Maximal weekly running distance	0.056	0.486	0.628
Number of training units	-0.133	-1.447	0.151
Speed in running training	-0.504	-6.586	0.000

r^2 = 0.45, adjusted r^2 = 0.43, Standard error of estimate = 23.92, $F_{(5)}$ = 19.80, $P < 0.0001$. Percent body fat and running speed during training were related to half-marathon race time.

performance times in the study of Arrese and Ostáriz (1) showed no positive correlation to skinfold thickness. They found high correlations between the front thigh and medial calf skinfold thickness with performance times of a 1,500 m and 10,000 m run, however, they did not include half-marathoners. In accordance with half-marathon, body mass index related to performance time in our study as well. Body mass index in the present half-marathoners was 23.3 kg/m^2. The 17 elite 10,000 m runners investigated by Arrese and Ostáriz (1) had a body mass index of 20.06 kg/m^2, which was clearly lower compared to the present runners. Percent body fat was apparently more important than body mass index.

Considering training, after multi-variate analyses, running speed during training related significantly to performance times of both marathoners and half-marathoners as the only predictor variable. In a comparable way, Knechtle *et al*. found an association between running speed in training and running

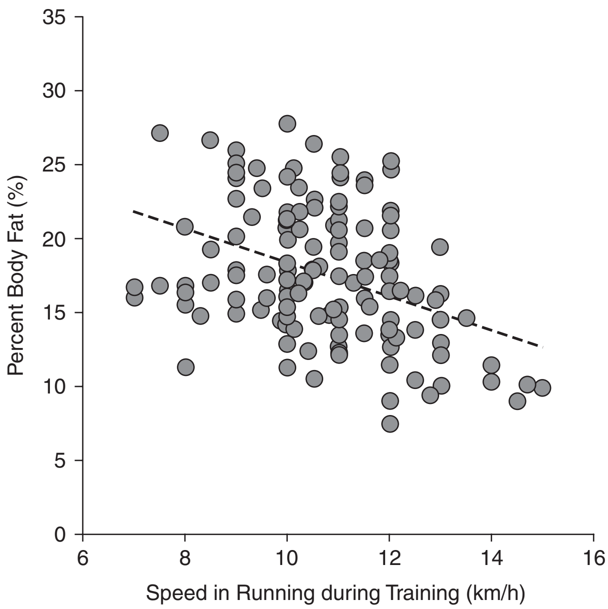

Fig. 1. For half-marathoners, percent body fat was significantly and negatively associates with speed in running during training (r = -0.39, P < 0.0001).

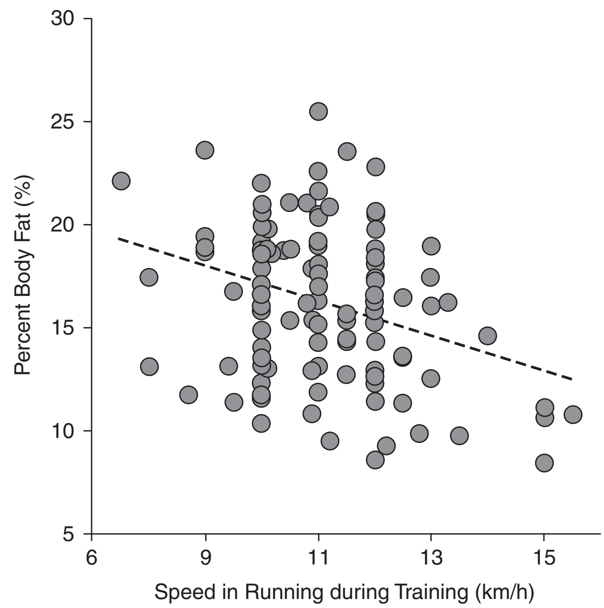

Fig. 2. For marathoners, percent body fat was significantly and negatively related to running speed during training (r = -0.33, P = 0.0002).

performance times for recreational female half-marathoners (16, 17). In a similar way, Scott and Houmard (31) described that in highly trained distance runners, the top running speed during training was significantly predictive for distance running performance in a 5 km run. Presumably, the running speed in training seems to be more important than volume and length in training for recreational male marathon and half-marathon runners.

Percent body fat was negatively related to running speed during training. One reason might be the loss of fat because of intense training. Legaz and Eston (20) described in their study of 37 elite runners that elite runners showed an explicit increase in performance and a decrease in the sum of six skinfolds, abdominal, front thigh, medial calf skinfolds and extremity/trunk skinfold ratio after years of training. They mentioned that the degree of performance was associated with the loss of skinfold thickness as a result of intense training. Worth mentioning are not only faster runners who did not improve their performance or showed a significant loss in skinfold thickness but also slower runners who demonstrated an improvement of performance with a decrease in skinfolds after their conditioning time period. Maybe faster elite runners already reached their limits. Additionally, Legaz and Eston (20) investigated a small number of elite runners. In contrast, we focused on recreational runners who have not reached their limits yet. Doubtless, a high training intensity can reduce skinfold thickness because of a higher lipid metabolism, but runners can also use special diets to reduce fat for a faster run. Recreational runners who might have less training times because of job related obligations might use nutrition to reduce their running mass. Genetic disposition will play a role in this part, too. In connection with our results, recreational runners should focus on a small percent body fat and a high speed during training to complete a fast half-marathon or marathon.

This cross-sectional study is limited that variables such as environmental temperatures (9, 10, 24), psychological aspects (25), physiological parameters (23, 28, 34), pre-race nutrition and nutrition during the marathon (5) and electrolyte changes like exercise-associated hyponatremia (8) were not investigated. These variables might also have an influence on race time.

Conclusion

To summarize, recreational half-marathoners showed differences in both anthropometry and training characteristics compared to recreational marathoners that could be related to their lower training volume, most probably due to the shorter race distance they intended to compete. For a practical application, race time might be partially predicted by the equation: Race time (min) = 115.7 + 2.052 × body mass index (kg/m^2) – 5.346 × speed in running during training (km/h) for half-marathoners, and by the equation: Race time (min) = 326.3 + 2.394 × percent body fat (%) – 12.06 × speed in running during training (km/h), for marathoners. Both groups of athletes seemed to profit from low body fat and a high running speed during training for fast race times. The take-home message is that differences in anthropometric and training characteristics do exist between half-marathoners and marathoners but for both half-marathoners and marathoners, both a low body fat and a high running speed during training are associated with fast race times.

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