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A Comparison of Anthropometric and Training Characteristics between Recreational Female Marathoners and Recreational Female Ironman Triathletes

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Abstract

A personal best marathon time has been reported as a strong predictor variable for an Ironman race time in recreational female Ironman triathletes. This raises the question whether recreational female Ironman triathletes are similar to recreational female marathoners. We investigated similarities and differences in anthropometry and training between 53 recreational female Ironman triathletes and 46 recreational female marathoners. The association of anthropometric variables and training characteristics with race time was investigated using bi- and multi-variate analysis. The Ironman triathletes were younger ($P < 0.01$), had a lower skin-fold thickness at pectoral ($P < 0.001$), axillar ($P < 0.01$), and subscapular ($P < 0.05$) site, but a thicker skin-fold thickness at the calf site ($P < 0.01$) compared to the marathoners. Overall weekly training hours were higher in the Ironman triathletes ($P < 0.001$). The triathletes were running faster during training than the marathoners ($P < 0.05$). For the triathletes, neither an anthropometric nor a training variable showed an association with overall Ironman race time after bi-variate analysis. In the multi-variate analysis, running speed during training was related to marathon split time for the Ironman triathletes ($P = 0.01$) and to marathon race time for the marathoners ($P = 0.01$). To conclude, although personal best marathon time is a strong predictor variable for performance in recreational female Ironman triathletes, there are differences in both anthropometry and training between recreational female Ironman triathletes and recreational female marathoners and different predictor variables for race performance in these two groups of athletes. These findings suggest that recreational female Ironman triathletes are not comparable to recreational female marathoners regarding the association between anthropometric and training characteristics with race time.

Key Words: skin-fold thickness, boy fat, swimming, cycling, running

Introduction

Triathlon is an endurance sports discipline consisting of the three disciplines swimming, cycling and running. Nowadays, triathlon races are held over the short or Olympic distance covering 1.5 km swimming, 40 km cycling and 10 km running (14), the Ironman distance over 3.8 km swimming, 180 km cycling and 42.195 km running (11, 30) and distances longer than the Ironman covering two to ten times the Ironman distance (19). The Ironman distance is of high popularity (http://ironman.com) and every year tens of thousands of athletes try to qualify in different qualifying races for the Ironman Hawaii, the Ironman World championship (http://ironman.com/worldchampionship).

Regarding the participation by gender, males dominate long-distance triathlons. In long-distance

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races, females account for ~10% of the participants (19). In recent years, several studies tried to determine predictor variables for an Ironman race time, especially for male Ironman triathletes. Percent body fat (21, 22), the sum of upper body skin-fold thicknesses (20), the personal best time in both an Olympic distance triathlon (11, 23, 33) and a marathon (23, 33) were related to an Ironman race time for male Ironman triathletes. In a recent study of male Ironman triathletes, running speed during training, a personal best time in a marathon and a personal best time in an Olympic distance triathlon were related to the Ironman race time (23). These three variables explained 64% of the variance in the Ironman race time (23). In another study, the previous best performance in an Olympic distance triathlon, coupled with the weekly cycling distances and the longest training ride, could partially predict an overall Ironman race performance when both male and female Ironman triathletes were included (11).

For female Ironman triathletes, however, there is limited data regarding predictor variables for an Ironman race time. Leake and Carter (26) reported that training parameters were more important than anthropometric measurements in the prediction of performance for 16 female triathletes. In studies investigating small samples of recreational female Ironman triathletes, weekly training hours (21, 22), personal best times in an Ironman triathlon (21, 24), personal best time in a marathon (24, 34), and personal best time in an Olympic distance triathlon (24, 34) were related to an Ironman race time.

In contrast to the sparse literature regarding predictor variables for Ironman race time, more data do exist regarding predictor variables for runners (1, 2, 9, 12, 15, 28). Among the anthropometric characteristics, the association of skin-fold thickness with running performance has been discussed for a number of years. Hagan *et al*. demonstrated that a low sum of seven skin-fold thicknesses was correlated to fast marathon performance times (12). Bale *et al*. reported that the total sum of skin-fold thicknesses, the type and frequency of training, and running experience such as the number of years running were the best predictors of running performance and success in the 10,000 m running distance (2). Also Arrese and Ostáriz reported high correlations between both the front thigh and the medial calf skin-fold thickness and performance over 1,500 m in highly trained male runners and correlations between the front thigh skin-fold and the medial skin-fold and 400 m distance in female top athletes (1). A correlation of the thickness of selected skin-folds with running performance has been reported for the top-class runners of distances from 100 m to 10,000 m and the marathon distance (1, 9, 28). High correlations were found for the front thigh and medial calf skin-fold thickness with 10,000 m race times in top-class male runners. Marathon race times and both the iliac crest skin-fold and the abdominal skin-fold were associated in top-class female runners (1).

The evidence suggests gender-specific differences of skin-folds in the prediction of marathon performance times (29). There are differences between the genders, their skin-fold thicknesses and the correlation with race times. Recent studies investigating recreational male and female half-marathoners (17, 18) described positive correlations between both the abdominal and calf skin-fold thicknesses and the race time in recreational male half-marathoners (17), whereas in recreational female half-marathoners, positive correlations between the pectoral, mid-axilla, subscapular, abdominal and suprailiacal skin-fold thickness and half-marathon race times were described (18).

For runners, an association between volume and intensity of training sessions and the running performance exists (2). The number of training session days, the number of total training sessions, the average number of kilometres covered per training session, the total and the longest distance covered during a training session, the total of training minutes, the average and the maximal run per week, and the average distance covered per day were related to marathon performance times (12, 13, 41). Yeung *et al*. reported, that in marathon finishers, the marathon performance was related to the longest mileage covered per training session (41). In female marathon runners, the number of years training and the number of training sessions per week were the best predictors of competitive performances at the marathon distance (3). However, not only the training volume, also the intensity of the training sessions was important. Billat *et al*. showed that top marathon runners trained for more total kilometres per week, and at a higher speed, than runners at a lower level (7).

The personal best time in a marathon seems to be a strong predictor variable for female Ironman race time (24, 34) and this finding raises the question whether female Ironman triathletes are similar to female marathoners. Since characteristics of both anthropometry and training were related in both marathoners and Ironman triathletes to their specific races times, we intended to investigate whether recreational female marathoners and recreational female Ironman triathletes were similar regarding anthropometry and training. Our hypothesis was that the two groups of athletes would show no significant differences in both their training parameters and anthropometric measures. To test this hypothesis, we compared variables of anthropometry and training from a sample of recreational female marathoners with the results of a different sample of recreational female Ironman triathletes.

Materials and Methods

Subjects

We performed a cross-sectional observational field study at 'Basel Marathon' in Basel, and 'Ironman Switzerland' in Zurich, Switzerland. Since participation of female endurance athletes is low in long-distance triathlons such as an Ironman triathlon (10, 23), we collected data in 'Ironman Switzerland' from 2007 to 2010 and in 'Basel Marathon' from 2010 to 2011 in order to increase the sample size. The organizers of both races contacted all the female athletes *via* a newsletter three months before each race and asked them to participate in this investigation. We focused on recreational female athletes where a recreational athlete is defined as an athlete pursuing a regular occupation, performs her sport during leisure time, has no sponsors and earns her livelihood neither through sponsorship nor by prize money. In 'Ironman Switzerland' a total of 59 recreational female Ironman triathletes volunteered to participate in the investigation. Fifty-three participants out of our study group (89.9%) finished the race successfully within the time limit of 16 h. Six triathletes had to give up during the run due to medical complications such as exhaustion and overuse injuries of the lower limbs. In 'Basel Marathon', a total of 46 recreational female marathoners volunteered to participate, they all finished the marathon within the time limit of 5:30 h:min. The study was approved by the Institutional Review Board for use of Human subjects of the Canton of St. Gallen, Switzerland. The participants were informed of the procedures and gave their informed written consent.

Races

The 'Ironman Switzerland' is generally held in July near Zurich. The athletes had to swim two laps in Lake Zurich to cover the 3.8 km and then they had to cycle two laps of 90 km each, followed by running four laps of 10.5 km each. In the cycling section, the highest point to climb from Zurich (400 m above sea level) was the 'Forch' (700 m above sea level), while the running course was completely flat in the City of Zurich. The 'Basel Marathon' takes place in September in the City of Basel, Switzerland. The athletes start at 08:30 a.m. and have to run two laps on asphalt in the City with a total altitude of 200 m. In both races, the organizer provides food and fluids at several aid stations. No athlete was included twice and no athlete competed in both races.

Measurements and Calculations

The afternoon the day before the start of the race body mass, body height, the circumferences of limbs (upper arm, thigh, and calf), and the thicknesses of skin-folds at eight sites (pectoralis, axillar, triceps, subscapular, abdomen, suprailiacal, thigh, and calf) were measured on the right side of the body. With the results of these measurements, percent body fat and skeletal muscle mass were estimated using anthropometric methods. 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 1.0 cm. The circumferences of the limbs were measured using a nonelastic tape measure (KaWe CE, Kirchner and Welhelm, Germany) to the nearest 0.1 cm. The circumference of the upper arm was measured at mid-upperarm, the circumference of the right thigh was taken at mid-thigh and the circumference of the right calf was determined at mid-calf. The skin-fold data were obtained using a skin-fold caliper (GPM-Hautfaltenmessgerät, Siber & Hegner, Zurich, Switzerland) and recorded to the nearest 0.2 mm. The skin-fold measurements were taken once for all eight skin-folds and then the procedure was repeated twice more and the mean of the three times was then used for the analyses. The timing of the taking of the skin-fold measurements was standardized to ensure reliability. According to Becque *et al.*, readings were performed 4 s after applying the calliper (5). One trained investigator took all the skin-fold measurements as inter-tester variability is a major source of error in skin-fold measurements. An inter-tester reliability check was conducted on 11 female runners prior to testing. Intra-class correlation (ICC) within the two judges was excellent for all anatomical measurement sites (ICC > 0.9) (16). Percent body fat was calculated using the following anthropometric formula for women: Percent body fat = $-6.40665 + 0.41946(\Sigma 3SF) - 0.00126(\Sigma 3SF)^2 + 0.12515$ (hip) + 0.06473(age), according to Ball *et al.* (4). This equation was chosen due to the fact that it is the latest formula cited in PUBMED (www.ncbi.nlm.nih.gov/pubmed/) to estimate percent body fat in females and the authors developed the equation after measuring 150 women. The circumference of the hip was determined at the level of the *trochanter major* to the nearest 0.1 cm. Skeletal muscle mass (SMM) was estimated using the formula of Lee *et al.* (27) with SMM = Ht $\times$ $(0.00744 \times CAG^2 + 0.00088 \times CTG^2 + 0.00441 \times CCG^2) + 2.4 \times$ sex $- 0.048 \times$ age + race + 7.8 where Ht = height, CAG = skin-fold-corrected upper arm girth, CTG = skin-fold-corrected thigh girth, CCG = skin-fold-corrected calf girth, sex = 1 for male and 0 for female; age is in years; race = 0 for white.

Table 1. Comparison of anthropometry and training between Ironman triathletes and marathoners

	Ironman Triathletes (n = 53)	Marathon Runners (n = 46)	Significance
Age (years)	37.0 ± 6.7	47.1 ± 8.7	**
Body mass (kg)	59.9 ± 5.9	59.1 ± 6.3	
Body height (m)	1.67 ± 0.06	1.66 ± 0.06	
Body mass index (kg/m^2)	21.3 ± 1.6	21.3 ± 1.6	
Circumference upper arm (cm)	26.4 ± 1.5	26.3 ± 1.7	
Circumference thigh (cm)	53.1 ± 2.9	54.1 ± 3.5	
Circumference calf (cm)	36.0 ± 2.1	36.2 ± 2.0	
Skin-fold pectoral (mm)	4.3 ± 2.0	6.9 ± 2.9	***
Skin-fold axilla (mm)	7.2 ± 2.0	8.7 ± 2.6	**
Skin-fold triceps (mm)	10.5 ± 4.6	12.2 ± 2.9	
Skin-fold subscapular (mm)	8.0 ± 2.8	10.5 ± 4.4	*
Skin-fold abdominal (mm)	11.7 ± 3.8	13.3 ± 5.7	
Skin-fold iliacal (mm)	14.1 ± 7.4	18.4 ± 6.6	
Skin-fold thigh (mm)	21.4 ± 9.4	23.3 ± 7.7	
Skin-fold calf (mm)	12.4 ± 7.5	9.1 ± 4.2	**
Sum of skin-folds (mm)	89.9 ± 33.0	102.7 ± 26.8	
Percent body fat (%)	23.8 ± 5.7	26.7 ± 4.2	
Skeletal muscle mass (kg)	27.7 ± 2.7	27.3 ± 2.2	
Weekly training hours (h)	14.1 ± 3.5	5.2 ± 1.2	***
Weekly swimming volume (h)	2.8 ± 1.1		
Weekly swimming volume (km)	6.2 ± 2.7		
Speed in swim training (km/h)	2.8 ± 0.6		
Weekly cycling volume (h)	7.4 ± 2.5		
Weekly cycling volume (km)	196.6 ± 83.5		
Speed in cycle training (km/h)	26.0 ± 3.6		
Weekly running volume (h)	4.1 ± 1.0	5.2 ± 1.2	
Weekly running volume (km)	41.0 ± 10.7	34.6 ± 12.0	
Speed in run training (km/h)	10.7 ± 1.4	9.7 ± 1.4	*

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

Upon inscription to the investigation, the athletes were asked to record their training units showing the distance and time for all three disciplines. Each athlete maintained a comprehensive training diary, recording all endurance training sessions showing distance and duration per discipline and training unit, since training volume is important for endurance athletes (35). The athletes also reported the number of their finished Olympic distance triathlons as well as their personal best time over this distance. The personal best time in Olympic distance triathlon was defined as the best time ever achieved over this distance.

Statistical Analyses

Data were checked for distribution of normality and are presented as mean and standard deviation (SD). Data for the Ironman triathletes and marathoners were compared using the Mann-Whitney U-test. The coefficient of variation (CV) of performance (CV% = 100 × SD/mean) was calculated. The coefficient of variation describes the magnitude sample values and the variation within them. To investigate a potential association between anthropometric and training characteristics with performance, in a first step, the relationship between both the split times and overall race time for the Ironman triathletes and marathon race time for the marathoners as the dependent variable and the variables of age, anthropometry, training and previous experience was investigated using bivariate Pearson correlation analysis. In a second step, all significant variables after bivariate 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. An alpha level of 0.05 was used to indicate significance for all statistical tests.

Results

The Ironman triathletes finished their race within 751 ± 89 min with a CV of performance of 11.9%. For the swim split, they invested 80 ± 11 min (CV = 14%).

Table 2. Association of anthropometric and training characteristics with race time. For Ironman triathletes, association with the split times are also inserted

	Ironman Triathletes (n = 53)				Marathon Runners (n = 46)
	Total Race Time	Split Time for Swimming	Split Time for Cycling	Split Time for Running	Total Race Time
Age	0.23	0.04	0.20	0.15	0.02
Body mass	0.05	-0.07	-0.05	0.18	0.37, $P = 0.04$
Body height	-0.17	-0.05	-0.23	-0.07	0.05
Body mass index	0.25	-0.02	0.17	0.31, $P = 0.0233$	0.46, $P = 0.01$
Length leg	-0.19	-0.07	-0.21	-0.12	0.05
Circumference of upper arm	0.16	0.01	0.03	0.30, $P = 0.0319$	0.27
Circumference of thigh	0.15	-0.12	0.01	0.32, $P = 0.0187$	0.51, $P = 0.004$
Circumference of calf	0.12	-0.07	0.02	0.33, $P = 0.0097$	0.41, $P = 0.02$
Skin-fold pectoral	-0.01	0.00	-0.07	0.01	0.04
Skin-fold axilla	0.24	0.18	0.11	0.28, $P = 0.0391$	0.33
Skin-fold triceps	0.07	0.09	-0.06	0.16	0.31
Skin-fold subscapular	0.03	0.05	0.19	0.04	0.32
Skin-fold abdominal	0.16	0.03	0.03	0.26	0.34
Skin-fold iliacal	0.18	-0.01	0.08	0.27, $P = 0.0484$	0.29
Skin-fold thigh	-0.03	-0.06	-0.12	0.05	0.38, $P = 0.04$
Skin-fold calf	0.08	-0.10	-0.01	0.17	0.40, $P = 0.02$
Sum of skin-folds	0.12	-0.01	-0.01	0.22	0.44, $P = 0.01$
Percent body fat	0.10	0.00	-0.03	0.20	0.41, $P = 0.02$
Skeletal muscle mass	-0.05	-0.13	-0.07	0.04	0.19
Weekly training hours	-0.20				-0.21
Hours of discipline-specific training		-0.25	-0.35, $P = 0.0104$	0.06	-0.21
Kilometres of discipline-specific training		-0.28, $P = 0.0438$	-0.36, $P = 0.0086$	-0.05	-0.22
Speed in discipline-specific training		-0.28, $P = 0.0462$	-0.16	-0.44, $P = 0.0009$	-0.60, $P = 0.0005$

P-value is presented in case of a significant association.

They completed the bike split within 382 ± 42 min (CV = 11%) and the run split within 282 ± 44 min (CV = 15.7%). The marathoners completed their marathon within 251 ± 29 min (CV = 11.5%). The Ironman triathletes were running their marathon during the Ironman triathlon at a mean speed of 9.2 ± 1.4 km/h, highly significantly slower ($P = 0.0002$) compared to the marathoners, running at 10.2 ± 1.1 km/h.

Table 1 shows the anthropometric and training characteristics for the two groups of athletes. The Ironman triathletes were younger ($P < 0.01$), had a lower skin-fold thickness at pectoral ($P < 0.001$), axillar ($P < 0.01$), and subscapular ($P < 0.05$) site compared to the marathoners. At the calf site, however, the marathoners had a lower skin-fold thickness ($P < 0.01$) compared to the Ironman triathletes. Overall weekly training hours were higher in the Ironman triathletes ($P < 0.001$) compared to the marathoners. The triathletes were running at a higher speed during training ($P < 0.05$) compared to the marathoners, but completed not more running kilometers per week during training ($P > 0.05$).

For the Ironman triathletes, after bi-variate analysis (see Table 2), neither an anthropometric nor a training variable showed an association with overall Ironman race time. For swimming, volume (r = -0.28, $P = 0.044$) and speed (r = -0.28, $P = 0.046$) during training showed significant associations with the corresponding race split times. For cycling, volume in hours (r = -0.35, $P = 0.01$) and kilometers (r = -0.36, $P = 0.008$) during training was related to race split times. Body mass index (r = 0.31, $P = 0.02$), the circumferences of upper arm (r = 0.30, $P = 0.03$) thigh (r = 0.32, $P = 0.01$), and calf (r = 0.33, $P = 0.009$), the skin-fold thicknesses at axillar (r = 0.28, $P = 0.04$) and iliacal (r = 0.27, $P = 0.04$) site and speed in running training (r = -0.44, $P = 0.0009$) were related to the marathon split time in the Ironman triathletes. For the marathoners, body mass (r = 0.37, $P = 0.04$), body mass index (r = 0.46, $P = 0.01$), the circumferences at thigh (r = 0.51, $P = 0.004$) and calf (r = 0.41, $P = 0.05$), the skin-fold thicknesses at thigh (r = 0.38, $P = 0.04$) and calf (r = 0.40, $P = 0.02$), the sum of skin-folds (r = 0.44, $P = 0.01$), percent body fat (r = 0.41, $P = 0.02$) and the speed in running during training (r = -0.60, $P = 0.0005$) were bi-variately related to the marathon race time. In the multi-variate analysis, running speed during training was related to

Table 3. Associations between significant characteristics after bivariate analysis and marathon split time using multiple linear regression for the Ironman triathletes (n = 53); β = regression coefficient; SE = standard error of the regression coefficient; the coefficient of determination (r^2) of the model was 19%. Running speed during training was related to marathon split time in the Ironman

Variables	β	SE	*P*
Body mass index	2.3	5.8	0.7
Circumference of upper arm	0.8	7.2	0.9
Circumference of thigh	2.1	3.3	0.5
Circumference of calf	-0.4	4.9	0.9
Skin-fold pectoral	-4.2	3.9	0.3
Skin-fold iliacal	1.2	1.7	0.3
Running speed during training	-6.9	4.7	0.01

Table 4. Associations between significant characteristics after bivariate analysis and race time using multiple linear regression for the marathoners (n = 46); β = regression coefficient; SE = standard error of the regression coefficient; the coefficient of determination (r^2) of the model was 41%. Speed of the training sessions was related to marathon race time

Variables	β	SE	*P*
Body mass	-1.3	1.2	0.3
Body mass index	4.7	4.2	0.3
Circumference of thigh	2.0	2.2	0.4
Circumference of calf	1.7	3.4	0.6
Percent body fat	-0.008	1.3	0.9
Running speed during training	-9.3	3.4	0.01

Table 5. Association of anthropometric characteristics with age and training variables in the Ironman triathletes (n = 53) and the marathoners (n = 46). *R*-values represent Pearson correlation coefficients. *P*-values are provided in case of a significant association

Ironman Triathletes	Age	Weekly Hours Run	Running Speed during Training
Pectoral skin-fold	-0.13	0.24	-0.16
Axillar skin-fold	-0.08	0.28	-0.17
Subscapular skin-fold	-0.04	0.26	-0.23
Calf skin-fold	-0.14	0.39, *P* = 0.004	-0.18

Marathoners	Age	Weekly Hours Run	Running Speed during Training
Pectoral skin-fold	-0.20	0.00	-0.13
Axillar skin-fold	0.03	-0.03	-0.19
Subscapular skin-fold	-0.08	0.03	-0.24
Calf skin-fold	-0.02	-0.10	-0.03

the marathon split time for the Ironman triathletes (*P* = 0.01) (see Table 3) and to the marathon race time for the marathoners (*P* = 0.01) (see Table 4).

Age, the skin-fold thicknesses at pectoral, axillar and subscapular and calf site, as well as weekly running hours and speed in running training were different between the Ironman triathletes and the marathoners. We investigated potential associations between these anthropometric and training variables for each group. The calf skin-fold thicknesses were related to weekly running hours in the Ironman triathletes (r = 0.39, *P* = 0.004), but not in the marathoners (r = -0.10, *P* > 0.05) (see Table 5). We found neither in the Ironman triathletes (r = -0.12, *P* = 0.4) nor in the marathoners (r = -0.01, *P* = 0.9) an association between age and percent body fat.

Table 6. Association of upper body skin-fold thicknesses, different between Ironman triathletes and marathoners, and swim training variables in the Ironman triathletes (n = 53). *R*-values represent Pearson correlation coefficients

Ironman triathletes	Weekly Swim Kilometers	Weekly Swim Hours	Speed in Swim Training
Pectoral skin-fold	0.20	0.27 $P = 0.04$	0.15
Axillar skin-fold	0.01	0.06	0.15
Subscapular skin-fold	0.16	0.33 $P = 0.01$	0.12

P-values are inserted in case of a significant association.

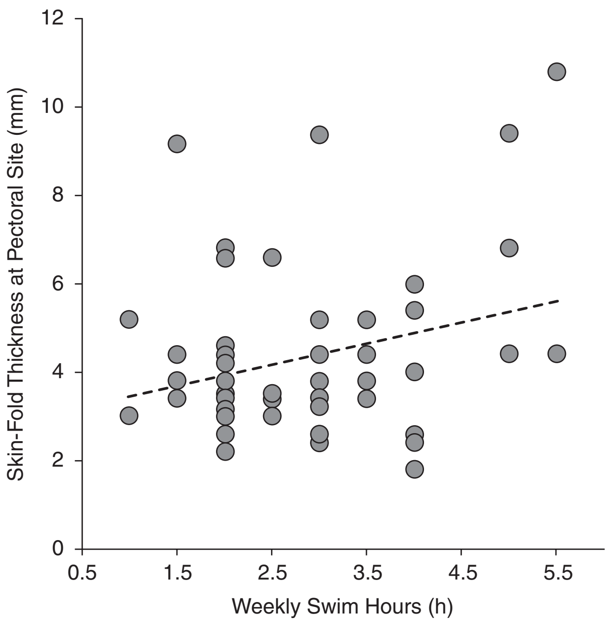

Fig. 1. The thickness of pectoral skin-fold was related to weekly swim hours in the Ironman triathletes (n = 53) (r = 0.27, *P* = 0.04).

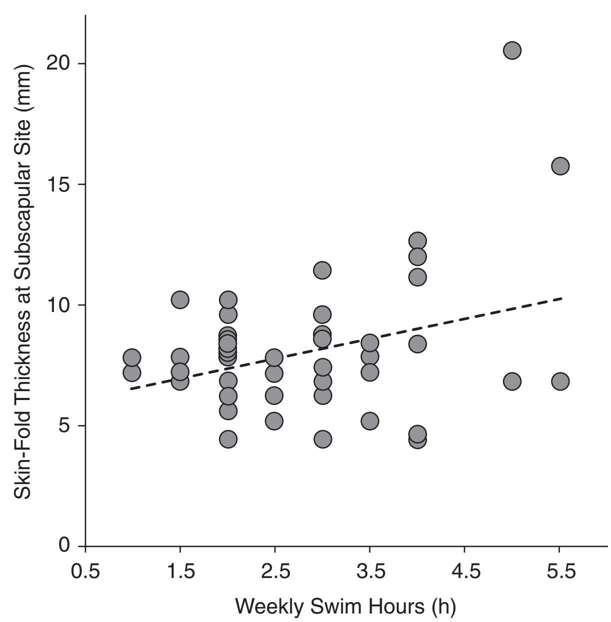

Fig. 2. The thickness of subscapular skin-fold was associated with weekly swim hours in the Ironman triathletes (n = 53) (r = 0.33, *P* = 0.01).

The Ironman triathletes had a lower skin-fold thickness at pectoral, axillar, and subscapular site and we investigated whether potential associations with swim training (see Table 6) do exist. Pectoral (see Fig. 1) and subscapular (see Fig. 2) skin-fold thicknesses were related to weekly swim hours during training. In the marathoners, skin-fold thicknesses of thigh (see Fig. 3) and calf (see Fig. 4) and the sum of skin-folds as well as speed in running training were related to marathon race times (see Table 2). Thigh skin-fold (r = -0.23, *P* = 0.2), calf skin-fold (r = -0.03, *P* = 0.9) as well as the sum of skin-folds (r = -0.2, *P* = 0.3) showed no relationship with running speed during training.

Discussion

The aim of the present study was to investigate whether recreational female marathoners and recreational female Ironman triathletes were similar regarding anthropometry and training. Since personal best marathon time was a strong predictor variable for Ironman race time in recreational female triathletes, we hypothesized that the two groups of athletes would show no significant differences in both their training parameters and anthropometric measures. However, the Ironman triathletes had a lower skin-fold thickness at upper body sites such as pectoral, axillar and subscapular site. The marathoners had a lower calf skin-fold thickness compared to the Ironman triathletes. Interestingly, the skin-fold thicknesses showed no relationship to overall race time in the Ironman triathletes. Regarding the marathon split in the triathletes, axillar and suprailiacal skin-fold thickness were related to marathon race times. In the marathoners, however, thigh and calf skin-fold thicknesses were

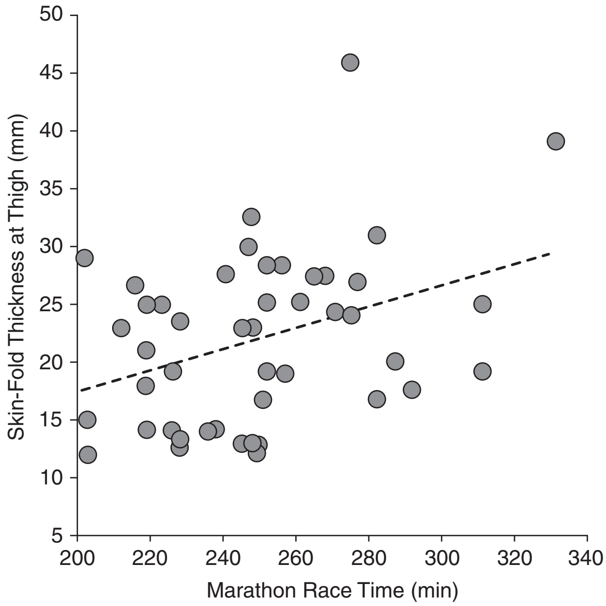

Fig. 3. The thickness of thigh skin-fold was related to marathon performance times in the marathoners (n = 46) (r = 0.38, *P* = 0.04).

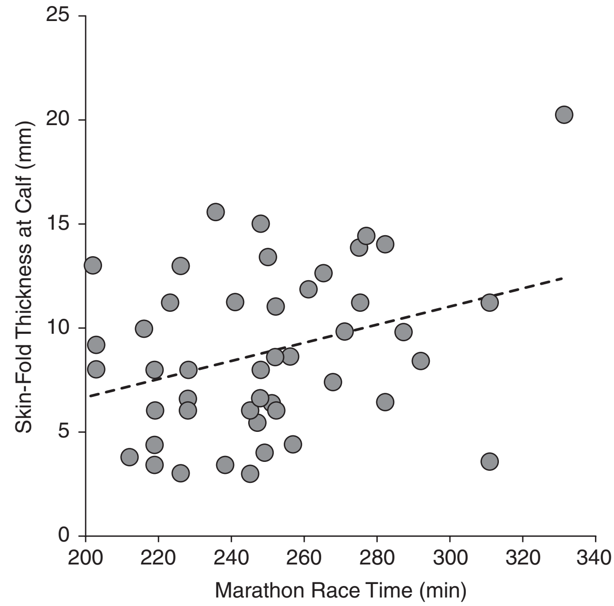

Fig. 4. The thickness of calf skin-fold was associated with marathon performance times in the marathoners (n = 46) (r = 0.40, *P* = 0.02).

related to marathon race times.

For female high-level runners, Arrese and Ostáriz (1) showed that skin-fold thicknesses of the upper and lower body were differently related to running performance regarding the distance the female runners were competing in. For female top marathoners, suprailiacal (r = 0.62, *P* = 0.042) and abdominal (r = 0.61, *P* = 0.046) skin-fold thicknesses were related to marathon performance times whereas front thigh (r = 0.71, *P* = 0.022) and medial calf (r = 0.81, *P* = 0.005) skin-fold thicknesses were associated with 400 m running times. In the present recreational female athletes, we can confirm that upper body skin-fold thicknesses are related to marathon performance times, but only in the Ironman triathletes. In the marathoners, skin-fold thicknesses at thigh and calf were related to marathon performance times. This might be explained by the subjects. Since we investigated recreational female marathoners, Arrese and Ostáriz investigated high-level marathoners (1). The marathoners of Arrese and Ostáriz had a sum of six skin-folds of 44 mm, whereas our recreational female marathoners had a sum of eight skin-folds of 102 mm (1). Also, the marathoners of Arrese and Ostáriz were considerably younger with 31 years compared to your marathoners with 47 years (1).

We found an association between upper body skin-fold thicknesses and variables of swim training and calf skin-fold thicknesses with variables of run training in the recreational female Ironman triathletes, but not in the recreational female marathoners. In the recreational female marathoners, neither the skin-fold thicknesses of the lower limb nor the sum of skin-folds were related to running speed during training although these variables were related to marathon performance times. One might assume that the discipline specific training may lead to changes in skin-fold thicknesses at that part of the body where the muscle groups perform contractions. Boschmann *et al*. showed that the lipolysis was greater in femoral adipose subcutaneous tissue than abdominal subcutaneous tissue when the subjects performed a cycle exercise (8). Legaz and Eston investigated the association between skin-fold thicknesses and training in 37 top-class runners (eight male and five female sprint trained, 16 male and eight female endurance trained) (28). Running training resulted in a significant increase in running performance and in a decrease in the sum of six skin-folds, abdominal, front thigh, and medial calf skin-folds. In the present recreational female athletes, calf skin-fold thickness was related to training in the recreational female Ironman triathletes, but not in the recreational female marathoners. These disparate findings might be explained by the samples. Legaz and Eston showed the significant associations between changes in skin-fold thicknesses and training in top-class runners, while we investigated recreational athletes (28).

Legaz and Eston also reported that the change in front thigh skin-fold thickness during training was related to performance in sprint trained runners (r = -0.74, *P* < 0.001) and medial calf skin-fold thickness was related to performance in endurance trained runners (r = -0.70, *P* = 0.008) (28). For the correlation of the front thigh skin-fold thickness, they combined eight female and 16 male runners; for the correlation of the calf skin-fold thickness, they combined five females and eight males. We can confirm that skin-fold thicknesses of the lower limbs were related to running times in the marathoners, but not in the Ironman triathletes.

Strength, Weakness, Limitations and Implications for Future Research

A strength of this study is the relatively high number of recreational female athletes included to investigate this topic although the absolute number seems relatively low. Gulbin and Gaffney (11) included 12 females in their study on 242 Ironman triathletes investigating race preparation. Also in other studies investigating female Ironman triathletes, the number of subjects was below 20 participants (21, 22). This study has some limitations. We did not include general weather conditions since both a marathon (10, 37, 38) and an ultra-marathon (32, 40) performance can be influenced by environmental temperatures. Also, physiological demands (6), nutrition (31) and fluid intake (39) may affect endurance performance. We found no similarities between these two groups of athletes, so presumably different motivations were the reason for the difference between the two groups. Stevinson and Biddle (36) investigated the motivation of recreational marathoners while Krouse *et al*. (25) investigated recreational female ultra-marathoners. While ‘hitting the wall” was predominant in the marathoners, female ultra-marathoners were task-oriented, internally motivated, health, and financially conscious individuals. Future studies might investigate the motivation between recreational female marathoners and recreational female Ironman triathletes.

To summarize, recreational female Ironman triathletes and recreational female marathoners showed differences in upper and lower body skin-fold thicknesses and speed in running training. The largest difference was that we found no predictor variable for the recreational female Ironman triathletes where, however, a high speed in running training was related to a fast marathon race time in both the recreational female Ironman triathletes and recreational female marathoners. Although personal best marathon time is a strong predictor variable for female Ironman triathletes, recreational female marathoners and recreational female Ironman triathletes are not comparable regarding their anthropometry and training. For practical application, these findings suggest that recreational female Ironman triathletes are not comparable to recreational female marathoners regarding the association between anthropometric and training characteristics with race time.

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