Skin-fold Thickness and Training Volume in Ultra-triathletes

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Abstract

We investigated the relationship between variables of anthropometry and training volume on race performance in 29 male non-professional ultra-triathletes. Anthropometric variables were determined in order to calculate body mass index, sum of skin-folds and percent body fat. Participants kept a comprehensive training diary recording their training volume in hours and kilometres in the 3 months before the race. The relationship of anthropometry and average weekly training volume with race performance was investigated with linear regression analysis. The sum of 8 skin-fold thicknesses was associated with total race time ($r^2=0.33$, $p<0.001$), whereas the average weekly training volume was not ($r^2=0.00$, $p>0.05$). The training volume showed no association with the sum of 8 skin-folds ($r^2=0.00$, $p>0.05$). The sum of 8 skin-folds was neither associated with speed in the swim ($r^2=0.10$, $p>0.05$) nor in the bike split ($r^2=0.10$, $p>0.05$) but showed a significant association with speed in the run split ($r^2=0.38$, $p<0.0001$). We concluded that anthropometry was of more importance than training volume in male Triple Iron triathletes and that these athletes were close to runners regarding the relationship of anthropometry with race performance.

Introduction

Long-distance triathlons such as an Ironman triathlon, which is competed over the distances of 3. 8 km swimming, 180 km cycling and 42 195 km running, are of increasing popularity. From year to year, more and more athletes participate in these races in order to qualify for the Ironman Hawaii World championship. However, apart from the Ironman distance even longer triathlons exist such as the Triple Iron triathlon, the distances in this being 11.4 km swimming, 540 km cycling and 126.6 km running [11, 12] and in which, for more than 20 years, an increasing number of athletes have also performed.

Finishing such a Triple Iron triathlon needs an enormous effort. The question is which kind of body anthropometry will sustain this type of ultra-endurance performance in the fastest possible time. In endurance athletes, different factors with relation to performance such as physiological, anthropometric and training parameters are described. A variety of anthropometric variables shows a relationship with endurance and race performance such as body mass [3, 19–21], body mass index (BMI) [6], body fat [6, 8, 13, 24], total skin-fold [3], skin-fold thickness of the lower limb [1, 3, 16, 17], body height [3, 5, 7, 18], length of the upper leg [23], length of limbs [5, 13], and circumference of thigh [23] and upper arm [9, 10, 23].

These anthropometric factors may have different associations with performance in different sports disciplines and over different distances. BMI is positively related to marathon performance times [6]. In addition to BMI, body fat seems to have an influence on running times. Body fat is positively associated with marathon performance times [6] and low levels of adiposity are important in elite triathletes for total performance time [13]. In some studies, a correlation of skin-fold thicknesses and performance has been described. Lower skin-folds are positively associated with improved running times up to 10 000 m [1, 3, 16, 17] and skin-fold thicknesses in the lower limbs are positively associated with running times over 1 500 m and 10 000 m [1, 3] as well as marathon running times [2]. Circumferences of thigh are positively associated with running times over 800 m, 1 500 m and 5 000 m

whereas upper arm circumference has a positive association with 10 000 m running times [23] and performance in multi-stage ultra-endurance runs [9, 10]. Body height seems to be negatively associated with running times in 10 km running [3] and the length of the upper leg has a positive association with running times over 800 m, 1 500 m and 5 000 m [23].
Triathletes are in the special situation of having to train and race in 3 different disciplines. In general in short-distance triathlons, low levels of adiposity are important for total time and most of the sub discipline times, and longer segmental lengths were important for a successful swimming outcome [13]. Elite triathletes are generally described as tall, of average to light weight and with low levels of body fat [22].
However, training variables seem to be more important than the anthropometric measurements in the prediction of performance as reported in a study using female triathletes [14]. We asked, therefore, whether anthropometry or training volume would be of more importance in successfully finishing an ultra-triathlon. The aim of this present investigation, therefore, was to investigate, in male non-professional Triple Iron triathletes, which of the variables - anthropometry or training - was of more importance for a successful finish in a Triple Iron triathlon.

Subjects and Methods

Subjects

All participants of the Triple Iron Triathlon Germany 2007 in Lensahn, Schleswig-Holstein, Germany, were contacted by a separate newsletter from the organiser 3 months before the start of the race and asked to participate in our investigation. Fifty-three athletes (3 women, 50 men) intended to start in the race. Forty-five male athletes entered our investigation. They all gave their informed written consent in accordance with the guidelines established by the Institutional Ethics Committee. No criteria for inclusion/exclusion were used. Twenty-nine male Caucasian non-professional ultra-triathletes with (mean and SD) 42.1 (8.1) years, 77 (7) kg, 1.77 (0.06) m and a BMI of 24.3 (1.7) kg/m^2 out of our study group finished the race successfully within the time limit of 58 h. Their anthropometric variables are listed in **Table 1**. Fifteen athletes dropped out during the race due to medical problems. The average weekly training volume, in hours and kilometres, of the successful finishers is summarised in **Table 2**.

Table 1 Anthropometric variables of the athletes (n = 29). The variables age, body mass, body height, skin-folds and circumferences were used to determine the calculated variables BMI, sum of 8 skin-folds and % BF.

Anthropometric variable	Result
age (years)	42.1 (8.1)
body mass (kg)	77 (7)
body height (cm)	177 (6)
length arm (cm)	79.1 (2.6)
length leg (cm)	85.1 (3.9)
C upper arm (cm)	31 (2)
C thigh (cm)	56.9 (2.8)
C calf (cm)	38.8 (1.9)
SF pectoral (mm)	6 (1.8)
SF axillar (mm)	7.9 (2.7)
SF triceps (mm)	8 (2.6)
SF subscapular (mm)	9.9 (2.9)
SF abdominal (mm)	15.9 (7)
SF suprailiacal (mm)	15.1 (5.9)
SF thigh (mm)	12.2 (4.6)
SF calf (mm)	6.5 (1.9)
BMI (kg/m^2)	24.3 (1.7)
sum of 8 skin-folds (mm)	81.8 (23)
percent body fat (% BF) (%)	15.3 (3.2)

SF = skin-fold thickness, C = Circumference. Values are given as mean (SD)

Table 2 Average weekly training volume in hours and kilometres of the athletes as well as speed in training in the sub disciplines in the preparation for the race (n = 29). Values are given as mean (SD).

Training variables	Result
total training volume (h/week)	19.5 (9.8)
hours of swimming per week	3.5 (2)
hours of cycling per week	10.2 (6.6)
hours of running per week	5.7 (2)
kilometres of swimming per week	9 (4.6)
kilometres of cycling per week	271 (139)
kilometres of running per week	59.4 (21)
speed in swimming (km/h)	2.6 (0.7)
speed in cycling (km/h)	27.4 (5.5)
speed in running (km/h)	10.3 (1.5)

The race

From 27th July to 29th July 2007, the 16th edition of the Triple Iron Triathlon Germany took place in Lensahn, Schleswig-Holstein, Germany. This was held as a World Championship over the distances of 11.6 km swimming, 540 km cycling and 126.6 km running. On Friday 27th at 07:00 a.m., the race started. The swimming was in a 50 m heated outdoor pool with a temperature of 25 °C and wetsuits were allowed. After passing through the transition area, 67 laps of a hilly course of 8 km per lap had to be cycled in the surroundings of the town. After the cycling section, athletes had to change to the flat run course of 96 laps with 1.31 km per lap in the town of Lensahn. The cycling course was nearly free of road traffic whereas the running course was completely free of traffic and illuminated during the night. All athletes had their own support crew to provide nutrition and changes of clothing and equipment. The athletes had to arrive at the finishing line within 58 h. The weather on the first day was cloudy with heavy wind and the temperature rose to 20 °C. In the first night, some rain was falling and the temperature dropped to 12 °C. On Saturday, the sky was cloudy and the temperature rose to 20 °C. In the second night, the temperature dropped again to 12 °C, but did not rise higher on Sunday, when it rained heavily.

Measurements and calculations

The afternoon before the start of the race, every participant underwent anthropometric measurements in order to determine body mass (BM), percent body fat (% BF) and sum of 8 skin-fold thicknesses. BM was measured with the BIA balance Tanita BC-545 (Tanita Corporation of America Inc., Arlington Heights, IL, U.S.A.) to the nearest 0.1 kg.
% BF was calculated using the formula: $\% BF = 0.465 + 0.180(\Sigma 7SF) - 0.0002406(\Sigma 7SF)^2 + 0.0661(age)$, where Σ7SF = sum of skin-fold thickness of chest, midaxillary, triceps, subscapular, abdomen, suprailiac and thigh mean, according to Ball et al. [4]. Skin-fold thicknesses of chest, midaxillary (vertical), triceps, subscapular, abdominal (vertical), suprailiac (at anterior axillary), thigh and calf were measured with a skin-fold calliper (GPM-Hautfalten-

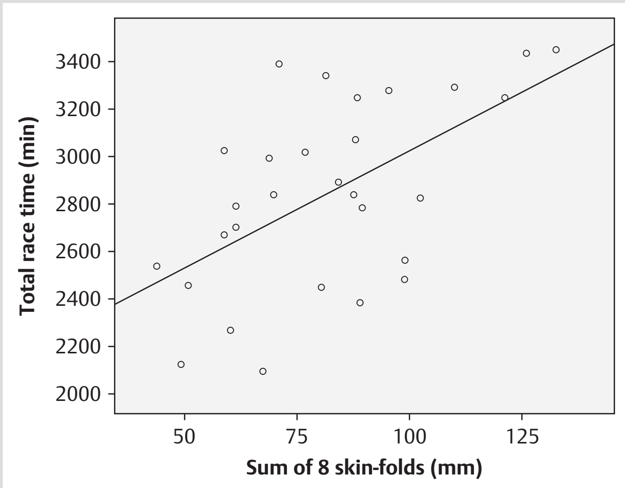

Fig. 1 The sum of 8 skin-folds was associated with total race time ($r^2 = 0.33$, $p < 0.001$). With a lower sum, race times were faster.

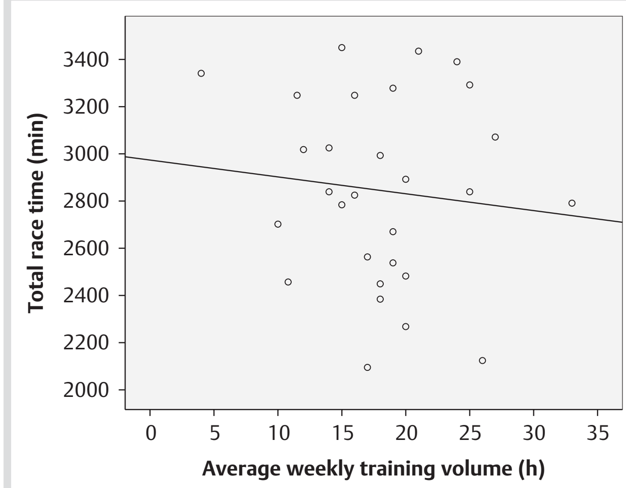

Fig. 2 Average weekly training volume was not associated with race performance (n = 29) ($r^2 = 0.00$, $p > 0.05$).

messgerät, Siber & Hegner, Zurich, Switzerland) to the nearest 0.2 mm on the right side, according to Lee et al. [15]. Each measurement of the anthropometric measurements was taken by the same person 3 times and then the mean value was used for calculation. In addition to the determination of the anthropometric variables, athletes were asked for their average weekly training volume in hours and kilometres in swimming, cycling and running over the last 3 months of preparation for the actual race. During these 3 months prior to the race each athlete maintained a comprehensive training diary consisting of daily workouts with distance and duration per discipline.

Statistical analysis

The results are presented as mean (SD). Data was analysed using SPSS software version 14 (SPSS Inc., Chicago, U.S.A.). Statistical analysis was assessed in 2 steps: In the first step we investigated, using linear regressions, the linear relationship between the measured and the calculated variables of anthropometry using scatter plots. The measured and the calculated variables all showed an association; we therefore reduced them to the calculated variables of anthropometry. In addition, the variables of training volume (hours and kilometres per week in total and per discipline) were investigated in the same way. These variables also showed an association so we reduced the variables to training volume in hours for the training variables. As a second step, a multiple linear regression analysis (stepwise, forward selection, p of F for inclusion < 0.05, p of F for exclusion > 0.1) was assessed in 3 parts: The relationship between the calculated anthropometric variables (sum of 8 skin-fold thicknesses, percent body fat, body mass index) and training volume (hours per week in total) as predictors on total race time (dependent variable), the relationship between the sum of 8 skin-folds (dependent variable) and speed in the race (km/h) in the 3 sub disciplines, and the relationship between speed in training (km/h) in the 3 sub disciplines and the sum of 8 skin-folds (dependent variable) were investigated in separate multiple linear regression analysis. Multicollinearity between the predictor variables was excluded with $R > 0.9$.

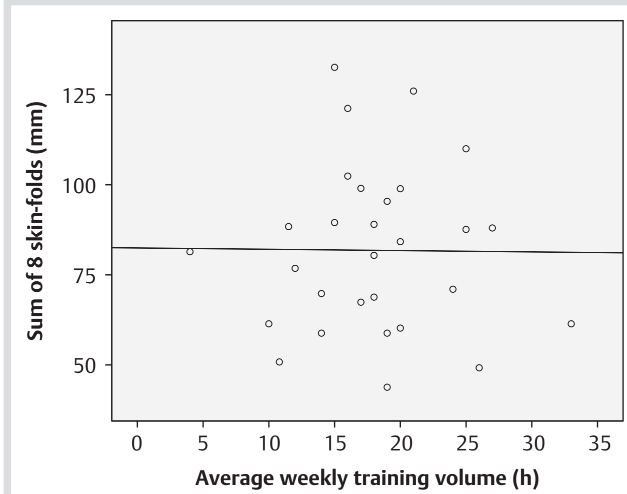

Fig. 3 The total training volume (average weekly hours) was not associated with the sum of 8 skin-folds (n = 29) ($r^2 = 0.00$, $p > 0.05$).

Results

▼

The 29 successful athletes finished the race within 47.4 (6.8) h and 27.5 (16.4) min. The fastest subject finished in 34:55 h: min, the slowest in 57:30 h: min. ◉ **Table 1** represents the measured and the calculated anthropometric variables of the athletes. ◉ **Table 2** shows their training variables including speed. During the race, speed in swimming (2.9 (0.4) km) was significantly faster ($p < 0.05$), in cycling (23.4 (3.1) km) highly significantly slower ($p < 0.001$) and in running (6.4 (1.3) km) also highly significantly slower ($p < 0.0001$) than during training. In the multiple linear regression analysis, the sum of 8 skin-fold thicknesses ($r^2 = 0.33$, $p < 0.001$) was associated with total race time (◉ **Fig. 1**), whereas the average weekly training volume ($r^2 = 0.00$, $p > 0.05$) was not (◉ **Fig. 2**). Percent body fat and body mass index showed no relationship with race time ($p < 0.05$). The training volume (average weekly hours) was not associated with the sum of 8 skin-folds ($r^2 = 0.00$, $p > 0.05$) (◉ **Fig. 3**). The sum of 8 skin-folds was neither associated with speed in the swim split

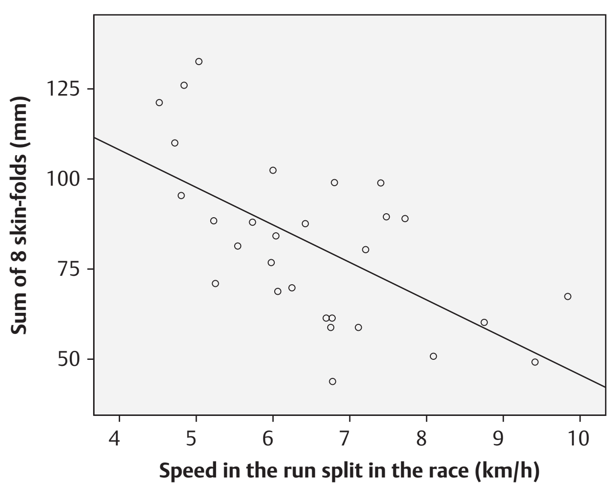

Fig. 4 Speed in the run split was significantly associated with the sum of 8 skin-folds (n = 29) (r^2 = 0.38, p < 0.0001).

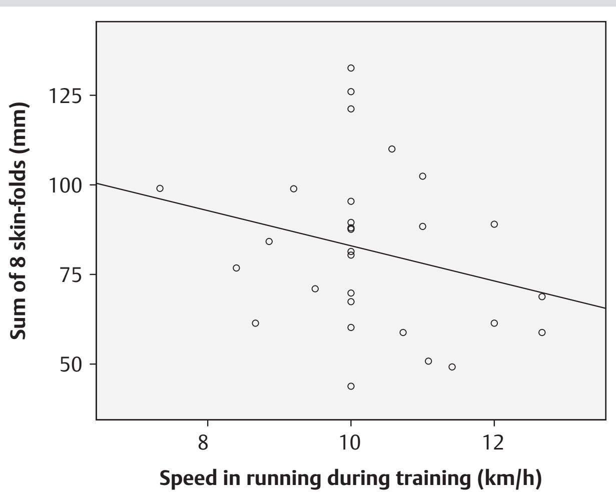

Fig. 5 Speed in running during training showed no influence on the sum of skin-folds (n = 29) (r^2 = 0.06, p > 0.05).

(r^2 = 0.1, p > 0.05) nor in the bike split (r^2 = 0.1, p > 0.05) but showed a significant association with speed in the run split (r^2 = 0.38, p < 0.0001) (**Fig. 4**). The speed in running during training was not related to the sum of 8 skin-folds (r^2 = 0.06, p > 0.05) (**Fig. 5**).

Discussion

The main finding of this investigation with male Triple Iron triathletes was that the total sum of 8 skin-folds as an anthropometric variable showed a relationship with race performance whereas the training volume showed no association.

Is there a relationship between anthropometry and race performance in ultra-triathletes?

Up to now, there was very little evidence as to whether anthropometry had an influence on race performance in triathletes, especially in ultra-triathletes. Landers et al. concluded from their study with short-distance triathletes, that low levels of adiposity are of importance for total race time and most sub disciplines, and longer segmental lengths also contributed to successful swimming outcomes [13]. According to recent studies over the Triple Iron distance, no correlates of anthropometry with race performance were demonstrated [11, 12]. The important fact of this present investigation was the finding that the anthropometric variable total sum of 8 skin-folds showed a relationship with race performance (**Fig. 1**) in contrast to training volume (**Fig. 2**). It seems that low levels of BF were advantageous for race performance in such an ultra-endurance race. Athletes with a low total sum of 8 skin-fold thicknesses finished the Triple Iron triathlon faster (**Fig. 1**).

Are male ultra-triathletes close to runners regarding anthropometry?

It seems from our results that male ultra-triathletes are very similar to runners from the anthropometric view of skin-fold thicknesses. The finding that total sum of skin-folds is associated with performance (**Fig. 1**) was first found in 1986 by Bale et al. in runners over 10 km [3]. Later, Arrese and Ostariz could show high correlations between the front thigh and medial calf skin-folds and the 1 500 m run time, and between the front thigh and medial calf skin-fold and the 10 000 m run time [1]. However, the sum of 6 skin-folds in their study was not associated with performance for any of the distances. It seems that with the increasing length of a running event the skin-fold thicknesses become more important. When marathon runners are compared to runners over shorter distances, all skin-fold thicknesses are significantly lower [16]. In our athletes, speed in the run split was significantly associated with the sum of 8 skin-folds (r^2 = 0.38, p < 0.0001) (**Fig. 4**). Apart from skin-fold thicknesses, BM [9, 18] and BMI [6] are known factors with a significant influence on performance in runners. However, in our ultra-triathletes, BMI showed no significant association either with total race time (r^2 = 0.05, p > 0.05) or with race performance in running (r^2 = 0.11, p > 0.05). In addition, BM had neither an influence on total race time (r^2 = 0.00, p > 0.05) nor on performance in the run split (r^2 = 0.01, p > 0.05).

Is training of less importance than anthropometry?

In contrast to anthropometry, training volume was not associated with race performance (**Fig. 2**). It is presumed that high training volume should lead to low BF as shown in male runners [16] and that intense training led to a significant decrease of the sum of 6 skin-folds in runners according to Legaz and Eston [17]. However, in our triathletes total training volume in hours per week showed no association with the total sum of the 8 skin-fold sites (r^2 = 0.00, p > 0.05) (**Fig. 3**). Also intensity in training showed no influence on skin-fold thickness in our athletes. Speed in running during training was not associated with the sum of 8 skin-folds in our athletes (r^2 = 0.06, p > 0.05) (**Fig. 5**). Probably the gender is of importance regarding the question of an influence of training volume on race performance. Leake and Carter compared body composition in swimmers, triathletes and runners [14]. They found no relationship of anthropometry with the prediction of performance and their conclusion was that training variables were more important than anthropometric measures in female triathletes.

Conclusions

In male ultra-triathletes over the Triple Iron distance, the sum of 8 skin-folds showed a relationship with race performance whereas other anthropometric measurements and variables of training volume showed no influence. We presume that anthropometry is of more importance than training volume in male Triple Iron triathletes and that these athletes are closer to runners as regards the influence of anthropometry on race performance.

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