Introduction

Ultra-endurance races are becoming more and more attractive and an increasing number of cyclists intend to start in ultra-cycling races such as the ‘Race Across AMerica’ (RAAM) in the USA or ‘Paris–Brest–Paris’ in Europe. There is very limited data concerning anthropometry in ultra-endurance cyclists and a question is whether a slim and light body, respectively low body fat is of importance in finishing such an ultra-cycling race.

In these ultra-cycling races, a considerable decrease in body mass has been described [1, 2], as already stated in shorter ultra-cycling races [3, 4]. In two case reports [1, 2] and two field studies [3, 4], anthropometric data including age, body mass, body height and body mass index of the cyclist and the loss of body mass were provided. In the two case studies, the athletes were riding for several days and lost substantially more body mass in the form of body fat [1, 2] than the cyclists in the two ultra-cycling races of less than one and a half day [3, 4].

Regarding body fat, the relationship between skinfold thicknesses and endurance performance has been intensely investigated in long-distance runners. Hagan et al. [5] demonstrated a correlation between the sum of 7 skinfold thicknesses and marathon performance time. Total skin-fold, the type and frequency of training and the number of years running were the best predictors of running performance and success at the 10 km distance according to Bale et al. [6]. In recent studies, a relationship between the thicknesses of selected skinfolds and running performance has been demonstrated in top class runners [7, 8]. Arrese and Ostáriz [7] showed high correlations between the front thigh ($r = 0.59$, $p = 0.014$) and medial calf ($r = 0.57$, $p = 0.017$) skinfold and 10,000 m running time. It is supposed that the thicknesses of the lower limb skinfolds are the result of intense training in running [8].

The relationship between skinfold thicknesses and race performance was investigated in all running distances from 100 m to 10,000 m and the marathon distance have been investigated [7, 8]. Arrese and Ostáriz [7] showed high correlations between the front thigh ($r = 0.59$, $p = 0.014$) and medial calf ($r = 0.57$, $p = 0.017$) skinfold and 10,000 m running time. It is supposed that the thicknesses of the lower limb skinfolds are the result of intense training in running [8].

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low body fat respectively low skinfold thicknesses would probably enhance performance and the training in the preparation for the race should lead to an association between skinfold thickness and training volume, respectively intensity in training.

We therefore hypothesized to find a correlation between skinfold thicknesses, respectively the sum of skinfold thicknesses and race performance. Furthermore, training volume and thickness of skinfolds should show an association.

Material and methods

Subjects

The organiser of the ‘Swiss Cycling Marathon’ contacted all participants of the race in 2007 by a separate newsletter, three months before the race, in which they were informed about the study. Athletes were asked about their average weekly training volume in hours and kilometres in cycling over the last 3 months in the preparation for the race. During these 3 months prior to the race, each athlete maintained a comprehensive training diary consisting of daily workouts with distance and duration in order to determine speed in cycling during training. Additionally, they reported their training volume in cycling kilometres over the past 12 months before the race. A total of 123 male non-professional cyclists started in order to qualify for the ultra-cycling marathon ‘Paris–Brest–Paris’. Thirty-six male athletes were interested in our investigation. Subjects were informed of the experimental risks and gave informed consent prior to the investigation. The investigation was approved by the Institutional Review Board for use of Human subjects. Twenty-eight cyclists with mean (SD) 42.3 (7.3) years, 78.3 (7.5) kg body mass, 1.81 (0.07) m body height and a BMI of 24.2 (1.9) kg/m² out of our study group finished the race successfully.

The race

The ‘Swiss Cycling Marathon’ took place from the 29th to 30th June 2007 as a non-stop ultra-cycling race from the outskirts of Bern (Switzerland) over the border to Germany, then along Lake Constance into the Alps of Eastern Switzerland and back to Bern. During this 600 km race, the athletes had to climb a total altitude of 4,630 m. The weather in Bern was fine and sunny, with 22 °C during the day and 11 °C in the night. Athletes were allowed to have a support crew with a car. About every 60 km, a checkpoint was set where every cyclist had to stop and register. Besides, food and drinks were served at these aid stations. A time limit was set at 40 hours.

Measurements and calculations

Before the start of the race, every participant underwent anthropometric measurements in order to determine body mass, body height and skinfold thicknesses at 8 sites in order to calculate the sum of 8 skinfold thicknesses and percent body fat. 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. Skinfold thicknesses of pectoralis, midaxillary (vertical), triceps, subscapular, abdominal (vertical), suprailiac (at anterior axillary), thigh and calf were measured using a skinfold calliper (GPM-Hautfaltenmessgerät, Siber & Hegner, Zurich, Switzerland) to the nearest 0.2 mm at the right side of the body. Percent body fat was calculated using the following anthropometric formula for men: Percent body fat = 0.465 + 0.180(Σ7SF) − 0.0002406(Σ7SF)² + 0.0661(age), where Σ7SF = sum of skinfold thickness of pectoralis, midaxillary, triceps, subscapular, abdomen, suprailiac and thigh mean, according to Ball et al. [9]. This formula was evaluated in 160 men aged 18–62 years and cross-validated using DXA (dual energy X-ray absorptiometry). 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. One trained investigator took all skinfold measurements as inter-tester variability is a major source of error in skinfold measurements. Intra-tester reliability check was conducted on 27 male runners prior to testing. No significant difference between the 2 trials for the sum of 8 skinfolds was observed (p > 0.05). The intra-class 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 (p > 0.05). The skinfold measurements were taken once through entire 8 skinfolds and then repeated 3 times by the same investigator; the mean of the 3 times was then used for the analyses. The timing of the taking of the skinfold measurements was standardised to ensure reliability. According
to Becque et al. [10], readings were performed 4 s after applying the calliper.

Statistical analysis

Data are presented as mean (SD). Speed in training and speed during race were compared with Wilcoxon signed rank test. The coefficient of variation (CV\% = 100 × SD/mean) of performance for total race time was calculated. The Pearson's correlation coefficient was used to test for univariate associations between speed in training and speed in the race with the anthropometric variables. Bonferroni correction was used to compensate for multiple testing effects. Significant p-values after Bonferroni correction were assumed at a level of \( p < 0.005 \) (\( n = 10 \) tests for the relationship between race time with the anthropometric variables, 8 single skinfolds, sum of 8 skinfolds and percent body fat).

Results

In the preparation of this race, the athletes were cycling 13.1 (4.7) h per week and were completing 340 (117) km. During training, the cyclists were riding at an average speed of 26.8 (5.7) km/h, significantly faster compared to speed in the race with 23.2 (3.7) km/h. The athletes reported a yearly training volume of 11,100 (4,700) cycling kilometres. The cyclists finished the race in a mean time of 1,596 (296) min (CV = 17.9 %). The relationship between the skinfold thicknesses and training volume, speed in training, race time as well as speed in the race is shown in Tab. 1. No association could be shown between the thickness of the single

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre race</th>
<th>Speed in training (km/h)</th>
<th>Training volume (km/week)</th>
<th>Race time (min)</th>
<th>Speed in the race (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF pectoral (mm)</td>
<td>8.4 (3.2)</td>
<td>–0.19</td>
<td>–0.24</td>
<td>0.29</td>
<td>–0.36</td>
</tr>
<tr>
<td>SF axillar (mm)</td>
<td>9.4 (3.5)</td>
<td>–0.16</td>
<td>–0.12</td>
<td>0.23</td>
<td>–0.29</td>
</tr>
<tr>
<td>SF triceps (mm)</td>
<td>9.1 (3.2)</td>
<td>–0.16</td>
<td>–0.16</td>
<td>0.30</td>
<td>–0.34</td>
</tr>
<tr>
<td>SF subscapular (mm)</td>
<td>12.1 (4.9)</td>
<td>–0.28</td>
<td>–0.16</td>
<td>0.17</td>
<td>–0.22</td>
</tr>
<tr>
<td>SF abdominal (mm)</td>
<td>20.2 (8.2)</td>
<td>–0.25</td>
<td>–0.24</td>
<td>0.28</td>
<td>–0.36</td>
</tr>
<tr>
<td>SF suprailiacal (mm)</td>
<td>16.4 (5.6)</td>
<td>–0.21</td>
<td>–0.26</td>
<td>0.20</td>
<td>–0.23</td>
</tr>
<tr>
<td>SF thigh (mm)</td>
<td>14.0 (5.5)</td>
<td>–0.20</td>
<td>0.24</td>
<td>0.15</td>
<td>–0.20</td>
</tr>
<tr>
<td>SF calf (mm)</td>
<td>7.1 (3.1)</td>
<td>–0.23</td>
<td>0.02</td>
<td>0.28</td>
<td>–0.35</td>
</tr>
<tr>
<td>Sum of 8 skinfolds (mm)</td>
<td>96.7 (28.7)</td>
<td>–0.28</td>
<td>–0.16</td>
<td>0.30</td>
<td>–0.38</td>
</tr>
<tr>
<td>Percent body fat (%)</td>
<td>17.3 (3.7)</td>
<td>–0.28</td>
<td>–0.17</td>
<td>0.35</td>
<td>–0.42</td>
</tr>
</tbody>
</table>

Results are presented as mean (SD); R-values are presented for all variables; no significant association has been found.
skinfolds, the sum of 8 skinfold thicknesses and percent body fat neither for speed in training and racing nor for training volume in cycling kilometres and total race time. Neither average weekly training volume (Fig. 1) nor average speed in training (Fig. 2) were related to race performance.

Discussion

In contrast to male long-distance runners [7] where a correlation between skinfold thicknesses at the lower limb and running performance has been shown, we could not detect an association between thickness of selected skinfold sites and race performance in these male ultra-endurance cyclists. A possible explanation for these different findings might be the kind of exercise since Arrese and Ostáriz [7] and also Legaz and Eston [8] investigated runners while we investigated cyclists. Running might lead to an increased decline in body fat since fat oxidation is increased during running compared to cycling [11, 12]. This might explain why Legaz and Eston [8] found an association between training volume and decrease in the sum of 6 skinfold thicknesses.

Arrese and Ostáriz [7] showed high correlations between the front thigh \((r = 0.59, p = 0.014)\) and medial calf \((r = 0.57, p = 0.017)\) skinfold thickness and 10,000 m running time in male high-level runners; however, no association between the sum of 6 skinfold thicknesses and both 10,000 m \((r = 0.42, p > 0.05)\) and marathon \((r = 0.13, p > 0.05)\) performance time. Running training leads to a decrease in skinfolds of the lower body. Legaz and Eston [8] could demonstrate a significant decrease in abdominal skinfold thickness \((p = 0.032)\), front thigh skinfold thickness \((p = 0.008)\), medial calf skinfold thickness \((p = 0.028)\) and the sum of 6 skinfold thicknesses \((p = 0.037)\) due to running training. Both in running and cycling muscles of the lower limb are used; a relationship between training and skinfold thickness at the lower limb has been found in long-distance runners, however, not in these ultra-endurance cyclists. Obviously cycling is not so intense and muscular work of these specific muscle groups seems to have no effect on the adipose subcutaneous tissue.

Legaz and Eston [8] suggested that intensity in training is related to thinner skinfolds. Training resulted in a significant decrease in the sum of 6 skinfold thicknesses and the thickness of abdominal, front thigh and medical calf skinfold in their investigation over a 3 year period. They concluded that the loss in body fat was specific to muscular groups used during training. We would therefore expect that ultra-endurance cyclists using their legs would show an association between the skinfold thickness of the lower limb such as thigh respectively calf and training volume or intensity during training. However, we could not find a relationship between average weekly training volume and training intensity with skinfold thickness (Tab. 1).

Arrese & Ostáriz [7] and also Legaz and Eston [8] did not report intensity or volume in training during running in their athletes. Training volume in our ultra-endurance cyclists was presumably too low to have an effect on body fat. On average, our ultra-cyclists trained for 340 km per week in the specific preparation for this particular race. This would amount to a calculated average yearly volume of 17,680 km. However, the athletes reported a yearly training volume of 11,100 (4,700) cycling kilometres in the preparation for the race. This value corresponds to the average yearly volume of a recreational ultra-endurance cyclist in an ultra-cycling marathon [13], whereas an elite professional road cyclist trains for about 24,000 kilometres during one season [14]. Since ultra-endurance events are not attractive for professional road cyclists, only recreational athletes race in these events. The fact of finding no association between both training volume (Fig. 1) and intensity during training (Fig. 2) with race performance might be explained.

A limitation of this investigation might be a rather small sample size of athletes. Unfortunately, the number of participants in ultra-endurance races is rather low compared to contests of shorter distances. Therefore the available data is small and statistical power is less than in other studies, such as the one performed by Arrese and Ostáriz [7] with 130 male runners. In contrast to the latter study, the volunteers in this study were part of the participants of the competition and the number of subjects was definitely limited to that number. Therefore, the power of the current study could not be increased by the number of participants. Arrese and Ostáriz [7] investigated a total of 130 athletes; however, in their subgroups, smaller sample sizes of 16 to 24 athletes were analysed. Likewise, Legaz and Eston [8] investigated a small group of 24 male runners. Coefficients of variance (CV) of performance in the male runners in Arrese and Ostáriz [7] varied between 2.13% and 3.36% whereas we had a CV of 17.9%. Presumably a larger cohort of ultra-endurance cyclists could show associations. A longitudinal study with a larger sample of ultra-endurance
cyclists could probably assess the influence of skin-fold thickness on performance.

Conclusions

In summary, this study showed no association between skinfold thicknesses and race performance in recreational male ultra-endurance cyclists in contrast to high-level long-distance runners. A longitudinal study to assess the influence of skinfold thickness on performance in a larger sample of ultra-endurance cyclists including elite cyclists is recommended. Since neither training volume nor intensity in training revealed an association with race performance, potentially other factors such as equipment, nutrition, previous experience and motivation might be of importance to endure such a competition.

References


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