

NO CORRELATION OF SKIN-FOLD THICKNESS WITH RACE PERFORMANCE IN MALE RECREATIONAL MOUNTAIN BIKE ULTRA-MARATHONERS

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Abstract

Introduction: A positive association between skin-fold thickness of the lower limb and race performance has been demonstrated in male high-level long-distance runners and a correlation between body fat and training is assumed.

Aim of the study: The purpose of this study was to examine the relationships of race performance in recreational mountain bike ultra-marathoners to physical characteristics and training indices.

Materials and methods: In 36 male recreational mountain bike ultra-endurance cyclists with 38.8 (9.0) years, 74.8 (7.7) kg, 1.79 (0.06) m and a BMI of 23.2 (1.9) kg/m² at the 'Swiss Bike Masters' (120 km length and 5,000 m of altitude), the skin-fold thicknesses at eight sites were measured. Body mass, percent body fat, skin-fold thicknesses and training variables were correlated to race time.

Results: The cyclists finished within 541 (81) min. There was no association between the sum of upper body skin-fold thickness, the sum of lower body skin-fold thickness, the sum of eight skin-fold thicknesses and percent body fat with both race time and yearly training volume in cycling. Race time was negatively correlated to yearly cycling volume in road cycling ($r = -0.42$), total yearly volume in both road and mountain bike cycling ($r = -0.30$) and average speed in road cycling during training ($r = -0.35$).

Conclusions: In recreational male mountain bike ultra-marathoners, no correlation between skin-fold thickness and race performance has been detected, as has been found in high-level long-distance runners. In contrast, volume and intensity in road cycling during training were significantly related to race performance.

Key words: anthropometry, ultra-endurance, body fat, training

Introduction

Ultra-endurance races are becoming more and more attractive and an increasing number of cyclists intend to start in ultra-endurance cycling races such as the 'Race across AMERICA' (RAAM) in the USA or 'Paris-Brest-Paris' in Europe. The question is what kind of body anthropometry is of importance in finishing such an ultra-cycling race since there is very limited data about anthropometry in ultra-endurance cyclists.

In these ultra-endurance cycling races, a considerably lower body mass can be found post race (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 of age, body mass, body height and body mass index of the cyclist including the loss in body mass were described. In the two case studies, the athletes were riding for several days and lost considerably 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 days (3, 4). Presumably long training rides would lead to slim and light bodies so probably training volume may also be an influencing factor regarding both body anthropometry and body fat.

In mountain bike races, body mass seems to be of importance (5, 6), since mountain bikers are lighter and leaner compared to road cyclists (6). In mountain-bikers in a cross-country race, total rider mass correlates strongly to average course speed (7) and according to Impellizzeri et al. (8), body mass is important for mountain bike performances. In addition, mountain bikers have anthropometric characteristics similar to road climbers (9). Apart from anthropometric parameters, volume and intensity in training and racing should also be considered. During a cross country race, mountain bikers race at high intensity (8, 10) and in road cyclists, long-term training programmes are important for the development of peak performance (11).

Regarding the association between body fat and performance, the relationship between skin-fold thickness and performance has been intensely investigated in long-distance runners. Hagan et al. (12) demonstrated that apart from other variables, the sum of seven skin-folds was correlated with marathon performance time. Total skin-fold thickness, the type and frequency of training and the number of years running

were the best predictors of running performance and success over the 10 km distance according to Bale et al. (13). In recent studies, a relationship between the thicknesses of selected skin-folds and running performance has been demonstrated in top class runners (14, 15). In these studies, elite runners of distances from 100 m to 10,000 m and the marathon distance had been investigated. High and positive correlations were found between both the front thigh and medial calf skin-fold thickness with 10,000 m race times in male high-level runners. It is supposed that the low skin-fold thicknesses of the lower limb are a result of intense training in running (15).

The relationship between skin-fold thicknesses and race performance was investigated in all running distances from 100 m to 10,000 m and the marathon distance in male top level runners; but not in long-distance cyclists such as ultra-endurance mountain bikers. We therefore intended to investigate whether correlations between skin-fold thicknesses and race performance in male ultra-endurance cyclists in a mountain bike ultra-marathon exist. Considering the fact that these ultra-endurance cyclists have to climb, in part, steep ascents, low skin-folds and, respectively, both low body mass and low body fat would probably enhance race performance. Furthermore, the training in cycling should show an association with skin-fold thickness as has been shown in high-level long-distance runners. We hypothesised about finding a correlation between skin-fold thickness and both training volume and race performance in ultra-endurance mountain bikers, as has been found in long-distance runners.

Materials and methods

Design

The study was performed as observational research. The organiser of the 'Swiss Bike Masters' 2008 contacted all 265 male participants of the race via a newsletter at the time of inscription to the race where the athletes were informed about the planned investigation. The 15th edition of the 'Swiss Bike Masters' took place on 20th July 2008. This race is among the five toughest mountain bike ultra-marathons in Europe. The athletes have to cover a total distance of 120 km with 5,000 m of altitude to climb. At the 06:35 a.m. start in the morning the temperature was 11 °Celsius and the weather was fine. At noon, the sky became covered over and in the afternoon after some showers heavy thunderstorms with lightning appeared. At the highest point of the race, 'Caschina' at 2,236 m above sea level, the temperature was 5 °Celsius with fog. Fluid and nutrition was provided at several aid stations. The study was approved by the Institutional Review Board for use of Human subjects of St. Gallen, Switzerland. Subjects were informed of the experimental risks and gave their informed written consent.

Subjects

Forty male athletes were interested and participated in our investigation. Thirty-six athletes with 38.8 (9.0) years, 74.8 (7.7) kg, 1.79 (0.06) m and a BMI of 23.2 (1.9) kg/m² finished within the time limit. The other four athletes did not finish due to medical complications such as exhaustion and diarrhoea; no athlete suffered an injury due to an accident.

Methodology

Before the start of the race, every participant underwent anthropometric measurements in order to determine total body mass, body height and skin-fold thicknesses to calculate BMI, percent body fat, the sum of 8 skin-fold thicknesses and both the sum of upper and lower body skin-fold thicknesses. Body mass was measured using a commercial scale (Beurer BF 15, Beurer, Ulm, Germany) to the nearest 0.1 kg. Skin-fold thicknesses of pectoralis, midaxillary (vertical), triceps, subscapular, abdominal (vertical), suprailiac (at anterior axillary), thigh and calf were measured using a skin-fold 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: Percent body fat = $0.465 + 0.180(\Sigma 7SF) - 0.0002406(\Sigma 7SF)^2 + 0.0661(\text{age})$, where $\Sigma 7SF$ = sum of skin-fold thickness of pectoralis, midaxillary, triceps, subscapular, abdomen, suprailiac and thigh mean, according to Ball et al. (16). This formula was evaluated using 160 non-athletic men aged 18 to 62 years old 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 ($P < 0.001$) and high ($r > 0.90$) correlations existed between the anthropometric prediction equations and DXA. In our study, one trained investigator took all the skin-fold measurements as inter-tester variability is a major source of error in skin-fold measurements. An intra-tester reliability check was conducted on 27 male runners prior to this actual study. No significant difference between the two trials for the sum of eight skin-folds 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 the testers ($P > 0.05$). The skin-fold measurements were taken once for the entire eight skin-folds and then the procedure was repeated three times by the same investigator; the mean of the three times was then used for the analyses. The timing of the taking of the skin-fold measurements was standardised to ensure reliability. According to Becque et al. (17), readings were performed 4 s after applying the calliper. At the time of inscription to the race, the athletes were asked

for their average weekly cycle training volume in hours and kilometres in preparation for the race. During the preparation for the race, each athlete maintained a comprehensive training diary, which consisted of daily workouts showing distance and duration, in order to determine intensity and volume during training. Furthermore, they indicated the yearly training volume based upon their records of training.

Statistical analysis

Data are presented as mean (SD). The coefficient of variation (CV % = $100 \times \text{SD}/\text{mean}$) for total race time was calculated. The relationship between race time and both anthropometric variables (body mass, percent body fat, the sum of the six upper body skin-fold thicknesses (pectoralis, midaxillary, triceps, subscapular, abdomen, suprailiac), the sum of the two lower body skin-fold thicknesses (thigh and calf) and the sum of all eight skin-fold thicknesses) and training variables (training volume in km per year in

mountain biking, training volume in km per year in road cycling, total training volume in km per year in cycling, average number of training units in cycling per week, average distance in km during one training unit in mountain biking, average duration in min of one training unit in mountain biking, average speed in km/h during training in mountain biking, average speed in km/h during training in road cycling), were analyzed using bivariate correlation analysis. Multiple regression analysis was used to investigate predictor variables for race time. An alpha level of 0.05 was used to indicate significance.

Results

The cyclists finished the race within 8.5 (1.4) h and 32 (16) min respectively 541 (81) min (CV = 14.9 %). Correlation coefficients (r) and coefficients of determination (r^2) relating race time to anthropometric and training variables are presented in Table 1 and Table 2. When all variables were considered together,

Table 1. The correlation of the anthropometric variables with race time. Results of anthropometry are presented as mean (SD). R values represent Pearson product-moment coefficients.

Anthropometric variables		r	r^2
Body mass (kg)	74.8 (7.7)	0.10	0.01
Percent body fat (%)	12.3 (2.7)	0.43	0.18
Sum of upper body skin-folds (mm)	44.4 (13.0)	0.31	0.14
Sum of lower body skin-folds (mm)	11.5 (5.4)	0.25	0.03
Sum of eight skin-folds (mm)	59.4 (17.4)	0.31	0.13

Table 2. The correlation of the training variables with race time. Results are presented as mean (SD). R values represent Pearson product-moment coefficients.

Training variables		r	r^2
Training volume per year in mountain biking (km)	2,434 (1,485)	0.14	0.02
Training volume per year in road cycling (km)	4,155 (3,229)	- 0.42	0.17 *
Training volume per year in cycling (total) (km)	6,595 (3,633)	- 0.30	0.09 *
Average number of training units in cycling per week	3.6 (1.4)	- 0.27	0.08
Average distance in one training unit in mountain biking (km)	43.5 (15.5)	- 0.40	0.16
Average duration of one training unit in mountain biking (min)	141.2 (59.3)	0.36	0.13
Average speed during training in mountain biking (km/h)	17.3 (3.8)	0.33	0.11
Average speed during training in road cycling (km/h)	25.0 (6.7)	- 0.35	0.12 *

* = $P < 0.05$.

Table 3. The correlation of the anthropometric variables with yearly cycling volume. Results of anthropometry are presented as mean (SD). R values represent Pearson product-moment coefficients. No significant association has been found.

Anthropometric variables	r	r^2
Body mass (kg)	- 0.15	0.06
Percent body fat (%)	- 0.28	0.14
Sum of upper body skin-folds (mm)	- 0.24	0.10
Sum of lower body skin-folds (mm)	- 0.15	0.02
Sum of eight skin-folds (mm)	- 0.23	0.09

the multiple linear regression analysis with both the anthropometric and training variables explained 67% of the race time. There was no association between the sum of upper body skin-fold thickness, the sum of lower body skin-fold thickness, the sum of eight skin-fold thicknesses and percent body fat with race time (Table 1). Race time was negatively and significantly correlated to yearly cycling volume in road cycling ($r = -0.42$), total volume in cycling ($r = -0.30$) and average speed during training in road cycling ($r = -0.35$) (Table 2). No relationship between percent body fat, the sum of upper body skin-fold thicknesses, the sum of lower body skin-fold thickness and the sum of eight skin-fold thicknesses with yearly training volume in cycling was found (Table 3).

Discussion

In contrast to male high-level runners where a correlation between skin-fold thickness at the lower limb and running performance has been shown (14), we could not detect an association between skin-fold thicknesses and race performance in these ultra-endurance cyclists.

According to Impellizzeri et al. (5, 8), body mass is related to performance in mountain bikers. We hypothesised that low body mass, especially low body fat, would enhance race performance due to the fact that mountain bike ultra-marathoners have to climb high altitudes with steep ascents. Body mass also has an influence on race performance in runners, dependent upon the distance (12, 13); however both body mass and body fat showed no association in these mountain bike ultra-marathoners (see Table 1) with race performance.

There are studies about anthropometry in track (18), endurance (19) and sprint (20) cyclists, but not for mountain bike ultra-endurance cyclists. Anthropometric parameters with an influence on performance are described for track and road cyclists. In endurance cyclists, small cyclists should be at a disadvantage in flat time trials but have an advantage in climbing (21). Large cyclists are at an advantage while cycling on level roads because they have a smaller quotient frontal area to body weight compared to small cyclists (19). Sprint cyclists are shorter than road and time trials cyclists (20). Time trialists are taller and have longer legs compared to sprint and road cyclists. McLean and Parker (18) demonstrated that sprint cyclists were heavier and had higher circumferences of chest, arm, thigh and calf than endurance cyclists. In these mountain bike ultra-marathoners, however, anthropometric variables showed no relationship to race time (see Table 1).

Low amounts of body fat seem to be advantageous for ultra-runners. Bale et al. (22) described in marathon runners that elite runners had a low percentage of fat and Hetland et al. (23) could demonstrate that

regional and total body fat correlated inversely to the performance in an incremental treadmill test in long-distance runners. In these ultra-endurance cyclists, however, no associations between body fat and race performance has been found. We might presume that a high training volume should lead to low body fat as shown in male long-distance runners (15). However, the yearly training volume in mountain bike cycling was not related to percent body fat in these mountain bike ultra-marathoners (see Table 3).

In contrast to the anthropometric variables, we found significant associations between both yearly training volume in cycling and speed in cycling during training with race time (Table 2). According to Schumacher et al. (11), long-term training is of outmost importance for success in elite cycling. Regarding the literature, training parameters seem to be of importance in the prediction of performance in endurance-runners (12, 13, 22). According to Christensen and Ruhling (24), improved performance in marathon runners is associated with higher aerobic capacity and years of training, not with body dimensions. In marathon finishers, the longest mileage covered per training session is the best predictor for a successful completion of a marathon (25), and the number of training sessions per week and the number of years training were the best predictors of competitive performance at the marathon distance (22). Scrimgeour et al. (26) found that runners training for more than 100 km per week have significantly faster race times over 10 to 90 km than athletes covering less than 100 km. According to Billat et al. (27), top class marathon runners train for more total kilometres per week and at a higher velocity than runners at a lower level. However, training volume seems to have clear limits. There exists an upper limit in training volume above which there are no more improvements (28).

In summary, we found no association between skin-fold thicknesses and race performance time in recreational male mountain bike ultra-marathoners as has been shown in high-level long-distance runners. In contrast, both volume and intensity in training were related to race time. We must assume that training is of more importance compared to anthropometry regarding success in this special kind of endurance performance. Obviously, mountain bikers seem to profit from intense road cycling during training. A longitudinal study to assess the influence of skin-fold thickness on performance in a larger sample of ultra-endurance cyclists including elite cyclists is recommended. Apart from anthropometry and training, potentially other factors such as equipment, nutrition, previous experience and motivation might be of additional importance to endure such a competition. This should be considered in future investigations with mountain bike ultra-endurance cyclists.

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