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Cycling and Running Performance, Not Anthropometric Factors, are Associated with Race Performance in a Triple Iron Triathlon

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CYCLING AND RUNNING PERFORMANCE, NOT ANTHROPOMETRIC FACTORS, ARE ASSOCIATED WITH RACE PERFORMANCE IN A TRIPLE IRON TRIATHLON

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Sixteen well-trained and well-experienced male Caucasian triathletes participated in World Championship Triple Iron Triathlon 2006 in Moosburg, Kärnten, Austria, which required athletes to perform 11.6 km swimming, 540 km cycling, and 126.6 km running within a time limit of 58 hours. Body mass, body height, skinfold thicknesses, circumferences of extremities, skeletal muscle mass, and body fat were measured. The results showed that race time was not significantly influenced by the anthropometric properties ($p > 0.05$). No significant influence was observed between race time and the calculated parameters of body mass index (BMI), body fat, and skeletal muscle mass ($p > 0.05$). In contrast,

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cycling performance (r^2 = 0.49, $p < 0.01$) and running performance (r^2 = 0.73, $p < 0.01$) are associated with total race performance. It summery, in an ultratriathlon, BMI, body height, skinfold thicknesses, circumference of extremities, skeletal muscle mass, and body fat have no influence on race performance in world-class ultratriathletes. Total race performance is associated with performance in cycling and running, not in swimming.

Keywords: endurance performance, ultraendurance, body mass index, skinfold thickness, body composition, percent body fat, skeletal muscle mass

INTRODUCTION

A variety of different factors influencing performance in endurance sports have been reported in the literature. Apart from physiological parameters, a variety of anthropometric parameters show an influence on performance in endurance athletes: body mass (Bale, Bradbury, and Colley 1986; Sharwood et al. 2002), BMI (Hagan et al. 1987), body fat (Hagan et al. 1987), length of the upper leg (Tanaka and Matsuura 1982), length of limbs (Landers et al. 2000), height (Bale et al. 1986; Maldonado et al. 2002), circumference of the thigh (Tanaka and Matsuura 1982), total skinfold (Bale et al. 1986), and skinfold thickness of the lower limb (Arrese and Ostariz 2006; Legaz and Eston 2005).

In an actual review Berg wanted to enhance knowledge of running performance such as body mass and its influence on performance (Berg 2003). Anthropometric properties and exercise performance during short- and middle-distance running, marathon, and triathlon have been investigated previously (Arrese and Ostariz 2006; Legaz and Eston 2005; Sharwood et al. 2002). Data from ultradistance performances is rare and often limited to case reports.

In this current investigation, anthropometric data of 16 successful finishers of the World Championship Triple Iron Triathlon 2006 were analysed with respect to their influence on the race time. We expected that BMI as well as fat mass and skeletal muscle mass would be important factors in predicting exercise performance. Furthermore, we assumed that fat mass might impair race performance.

SUBJECTS AND METHODS

Subjects

All participants of the Triple Iron Triathlon 2006 in Moosburg, Kärnten, Austria, were contacted by a separate newsletter from the organiser 3 months before the race and asked to participate in the study. A total of 30 athletes (3 women, 27 men) registered to compete in the triathlon. Twenty-two male white Caucasian triathletes entered the study. They all gave their informed written consent. From these subjects, 16 athletes (36.2 ± 8.5 years, 76.4 ± 9.2 kg, 178 ± 7 cm, BMI 23.8 ± 2.0 kg/m^2) finished the race successfully within the time limit. They trained 17 ± 5 hours per week in preparation for the race and had an average experience of 7 ± 8 (one to more than 30) extreme endurance races of 24 hours and longer prior to the actual race.

The Race

From June 15 to June 17, 2006, the First Triple Iron Triathlon Moosburg in Kärnten, Austria, which required 11.6 km swimming, 540 km cycling, and 126.6 km running, took place. The race was accepted as an official World Championship Triple Iron Triathlon of International Ultra Triathlon Association (IUTA) with the best ultratriathletes in the world competing. Five participants were ranked within the first 10 places of the IUTA World Circuit 2005, and the first 3 male athletes of the last World Championship in Triple Iron Triathlon were defending their medals. On Thursday, June 15, at 7:00 a.m., the race started. Swimming took place in a lake with a temperature of 23° Celsius, and wetsuits were allowed. Athletes had to swim 21 laps of 542.85 m with electronic lap counting. After passing the transition area, 90 laps of 6 km with an inclination of 25 m per lap were cycled in the town of Moosburg. After cycling, athletes started the running circuit of 60 laps of 2.11 km with an inclination of 5 m per lap in the town of Moosburg. The cycling and running courses were flat and on asphalt, were completely free of traffic, and were illuminated during the night. All athletes had their own support crew in order to provide nutrition and other needs. The athletes had to arrive at the finish line within 58 hours. The average finish time was 45 h 12 min, varying from 34 h 16 min for the defending world champion up to 56 h 10 min for the last successful finisher. The weather for the event was fine, with blue sky, a temperature of 33° Celsius, and no precipitation.

Measurements and Calculations

The evening before the start of the event, body mass and circumferences of upper arm, thigh, and calf were measured on the right side. Body mass (BM) was measured with a commercial scale (Beurer BF 15, Beurer GmbH, Ulm, Germany) to the nearest 0.1 kg. Skinfold thicknesses and circumferences of the extremities were measured on the right side of the body according to the protocol described by Lee et al. (2000).

Circumference of the upper arm and calf were measured at the largest perimeter of the limb and at the thigh 15 cm above the upper pole of the patella. All circumferences were measured to the nearest 0.1 cm. Skinfold (SF) thicknesses of chest, midaxillary (vertical), triceps, subscapular, abdominal (vertical), suprailiac (at anterior axillary), thigh, and calf were measured with a skinfold calliper (GPM-Hautfaltenmessgerät, Siber & Hegner, Zurich, Switzerland) to the nearest 0.2 mm. Every measurement was taken three times by the same person, and then the mean value was used for calculation. Skeletal muscle mass (SM) was calculated using the following formula: $SM = Ht \times (0.00744 \times CAG^2 + 0.00088 \times CTG^2 + 0.00441 \times CCG^2) + 2.4 \times sex - 0.048 \times age + race + 7.8$, where Ht = height, CAG = skinfold-corrected upper arm girth, CTG = skinfold-corrected thigh girth, CCG = skinfold corrected calf girth, sex = 1 for male, race = 0 for White (Lee et al. 2000). Percent of body fat (%BF) was calculated using the following formula: $\%BF = 0.465 + 0.180(\sum 7SF) - 0.0002406(\sum 7SF)^2 + 0.06619(age)$, where $\sum 7SF$ = sum of skinfold thickness of chest, midaxillary, triceps, subscapular, abdomen, suprailiac, and thigh mean (Ball, Altena, and Swan 2004). Body fat mass was calculated with %BF from body mass. Results of anthropometric measurements were correlated with race performances.

Statistical Analysis

Statistical analysis was performed with the R software package (R Development Core Team 2005). We assumed that the anthropometric properties of the athletes would influence their physical exercise performance. To identify the performance relevant factors, the directly measured anthropometric properties (body mass, body height, mean skinfold thickness, circumferences of upper arm, thigh, and calf), the calculated anthropometric properties (BMI, skeletal muscle mass, fat mass), as well as the competition times of the single disciplines (swimming, cycling, running) were correlated with total race time using Spearman's rank correlation analysis. A nonparametric correlation method was used as not all parameters were ideally normally distributed. For all statistical tests, the significance level was set to 0.05. The Bonferroni correction was applied to compensate for multiple testing effects (9 tests).

RESULTS

Table 1 shows the anthropometric data of the successful finishers before the race. The race time is not statistically significantly influenced by the directly measured anthropometric properties of limb circumferences of thigh, calf, and upper arm (Figure 1); the calculated parameters of BMI,

Table 1. The Anthropometric Properties of the Athletes in the World Championship Triple Iron Triathlon 2006 Before the Start of the Race

Parameter	Prerace value
Body mass (kg)	76.4 (9.2)
Body height (cm)	179 (7)
Average skin fold thickness (mm)	8.9 (3.8)
Upper arm circumference (cm)	29.9 (2.3)
Thigh circumference (cm)	53.7 (3.7)
Calf circumference (cm)	39.1 (3.1)
BMI (kg/m^2)	23.8 (2.0)
Skeletal muscle mass (kg)	40.0 (4.6)
Fat mass (kg)	10.2 (4.0)

The parameters are grouped as directly measured properties (body mass, height, average skin fold thickness, circumferences of extremities) and calculated properties (BMI, skeletal muscle mass and body fat mass) as used for the multiple regression analysis. Values are given as mean (SD).

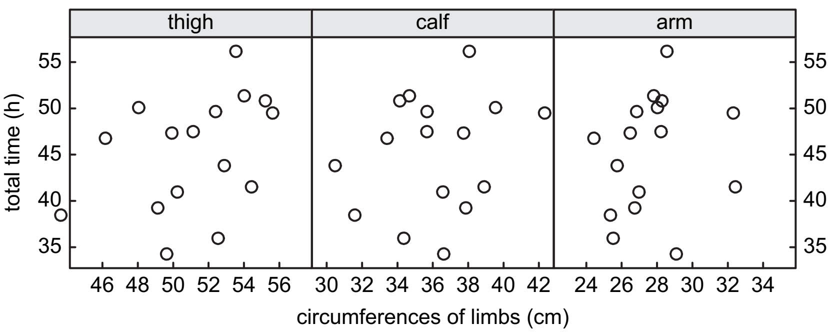

Figure 1. No association of limb circumferences with race performance. No significant influence is found between the running time and circumferences of the limbs (upper arm, upper leg, and lower leg) in the Triple Iron Triathlon Austria ($p > 0.05$).

body fat, and skeletal muscle mass (Figure 2); as well as body height, body mass, and mean skinfold thicknesses (Figure 3; $p > 0.05$). In contrast, cycling performance ($r^2 = 0.49$, $p < 0.01$) as well as running performance ($r^2 = 0.73$, $p < 0.01$) are associated with total race performance (Figure 4). The age of the participants (range: 23–50 y) is statistically not significantly correlated with the total race time ($r^2 = 0.08$; $p > 0.05$).

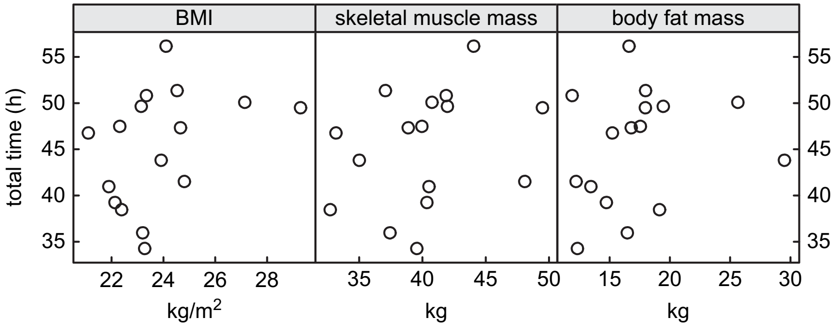

Figure 2. No association of BMI, skeletal muscle mass, and fat mass with race performance.

No significant influence is found between the running time and the calculated parameters BMI, skeletal muscle mass, and body fat mass in the Triple Iron Triathlon Austria ($p > 0.05$).

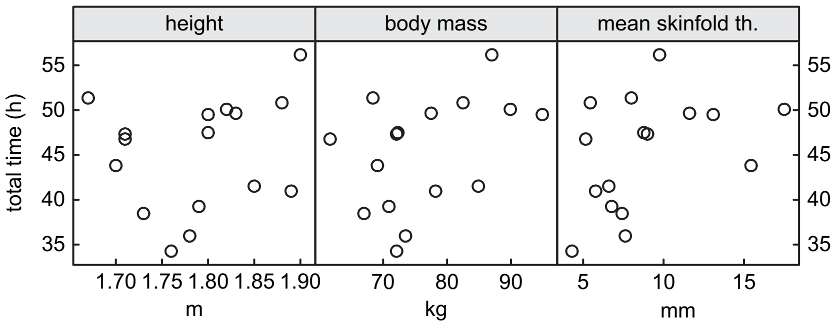

Figure 3. No association of body height, body mass, and mean skinfold thickness with race performance.

No significant correlation ($p > 0.05$) is indicated between the total competition time and height, body mass, and mean skinfold thicknesses.

DISCUSSION

The main finding of our investigation is the fact that we cannot confirm any of the previously found anthropometric factors such as body fat (Hagan *et al*. 1987), thigh girth (Tanaka and Matsuura 1982), total skin fold (Bale *et al*. 1986), BMI (Hagan *et al*. 1987), body mass (Bale *et al*. 1986, Sharwood *et al*. 2002) and skin fold thickness of the lower limb (Arrese and Ostariz 2006; Legaz and Eston 2005) influenced performance in this group of successful finishers of the ultra-triathlon.

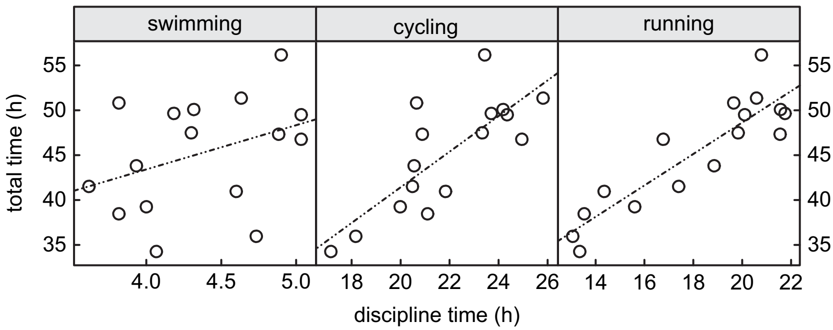

Figure 4. Association of time per discipline with total race time.
Correlation between the time per discipline and total race time. The squared correlation coefficient between total time and the discipline times is 0.09 for swimming, 0.49 for cycling, and 0.73 for running. In contrast to swimming, cycling and running performance is significantly correlated with total race time ($p < 0.01$).

In contrast to our ultra-triathletes, several anthropometric factors have been shown to influence performance in runners. The influence of weight, body mass, skin fold thicknesses and body fat is described in several studies with runners. We presume that there must be anthropometrical differences between triathletes and runners. Unfortunately, the number of participants in ultra-triathlon races is rather low in comparison 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 Ostariz (2006) with 130 male runners. In contrast to the latter study, the volunteers of our current study were part of the participants of a 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. Furthermore, other factors might influence competition time during extreme distance competitions. For example, temperature and nutrition might be of more importance in extreme endurance competitions than in shorter distance races. This fact could explain the findings of Leganz and Eston (2005) who reported significant influences of anthropometric properties in a similar number of top class runners.

Body Mass Index and Running Performance

The influence of BMI on performance is known in Kenyan runners. Although Black runners are reported to be smaller (Weston et al. 1999; Weston, Mbambo, and Myburgh 2000) and less heavy than White runners (Bosch et al. 1990; Noakes 1998; Weston et al. 1999), this was not confirmed in a study by Rahmani et al. (2004). The BMI of the Kenyan runners is 19.2 kg/m^2 compared with 20.6 kg/m^2 for the best Scandinavian runners (Saltin et al. 1995). When Senegalese and Italian runners were compared, the Black runners had longer and lighter legs (Rahmani et al. 2004). It is hypothesized that a lower BMI (Larsen 2003) and a smaller body size are important performance factors for Black runners (Marino, Lambert, and Noakes 2004). Apart from Kenyan runners, a relationship also exists in White female marathon runners between BMI and race performance. Marathon race times for White female marathon runners are positively correlated with BMI (Hagan et al. 1987). The absolute value of the BMI seems to be of importance. The BMI of our ultratriathletes is higher than the BMI of Kenyan runners. Our athletes have a BMI of 23.8 kg/m^2 (Table 1), which is clearly higher than the BMI of young Kenyan runners with a BMI of 18.6 kg/m^2 (Larsen et al. 2004) or adult Kenyan runners with 19.2 kg/m^2 (Saltin et al. 1995).

Influence of Body Fat on Performance in Runners

It is known from several studies that appropriate sport-specific levels of relative fat and fat-free weight are beneficial to performance in endurance sport. Body fat has an influence on performance in runners, due the fact that an excess of adipose tissue requires an increased muscular effort and therefore an increased energy expenditure. In former studies it has been shown that physical performance is negatively affected by body fat and positively related to skeletal muscle mass (Leedy et al. 1965; Riedenau et al. 1968). This could be confirmed in a recent study. The loss of body fat is specific to muscular groups used during training, and race performance is enhanced with decreased skinfold thickness at the lower limb (Legaz and Eston, 2005). Fat as adipose subcutaneous tissue seems to have a special influence in runners, especially in Black runners. Black runners have thinner skinfold measurements at the legs and arms (Bosch et al. 1990), suggesting a smaller amount of adipose subcutaneous tissue. In other studies, the influence of body fat on race performance is controversial. Whilst Hagan et al. (1987) found a positive correlation between marathon performance time and body fat, in female marathon runners, the percentage of body fat did not correlate with the finish time (Christensen and Ruhling, 1983).

Skinfold Thicknesses and Their Effect on Running Performance

In recent studies, the effect of skinfold thicknesses on running performance was investigated (Arrese and Ostariz 2006; Bale et al. 1986; Conley and Krahenbuhl 1989; Kenney and Hodgson 1985; Legaz and Eston 2005). In runners, decreased skinfold thicknesses in the lower limb are described and could be useful in predicting running performance (Legaz and Eston 2005).

Legaz and Eston (2005) found an association between the decrease in thigh skinfold thickness and improvement in performance. Bale et al. (1986) reported that total skinfold among other parameters, including type and frequency of training and the number of years running, were the best predictors of running performance and success at 10,000 m. Arrese and Ostariz (2006) showed a high correlation between the thigh and calf skinfold and 1,500 m as well as 10,000 m run time. In former studies, these effects were not described (Conley and Krahenbuhl 1989; Kenney and Hodgson 1985; Legaz Arrese et al. 2005). No differences have been reported in thicknesses of skinfolds among runners competing in classical distances ranging from 100 m to 10,000 m (Legaz Arrese et al. 2005). Conley and Krähenbühl (1989) reported no significant relationship between body fat and sum of skinfolds in an elite group of 10,000 m runners, and Kenney and Hodgson (1985) showed similar findings in 3,000 m steeplechase runners.

There are two major differences in the studies of Bale et al. (1986), Legaz and Eston (2005), and Arrese and Ostariz (2006) compared with our study. First, in these studies, running performances of 10,000 m and less were investigated. In contrast, our ultratriathletes had to run a total distance of 126.6 km. Second, the measured skinfold thicknesses of the lower limb seem to be different.

Ultra-athletes seem to have more fat than runners performing over shorter distances. Our ultratriathletes had a skinfold thickness of 9.5 ± 6.5 mm at the thigh and 7.1 ± 2.6 mm at the calf, compared with 9.4 ± 4.2 mm at the thigh and 4.6 ± 1.3 mm at the calf in the runners of the study of Legaz and Eston (2005).

The length of the running race seems to be of importance for the correlation between skinfold thickness and race performance. Arrese and Ostariz (2006) reported that marathon runners had a lower sum of 6 skinfolds than runners of distances up to 10,000 m. They concluded that marathon runners undertake a higher training volume and that in marathon running fat metabolism prevails in training and competition. Interestingly, the ultraathletes in this study had a higher sum of 6 skinfolds compared with the marathon runners described by Arrese and Ostariz (2006). The value of 56.7 mm for our triathletes is around the value of 61.7 mm for the 3,000 m runners of Arrese and Ostariz (2006). Probably the average training volume of 17 ± 5 hours per week of our ultratriathletes is too low compared with classical marathon runners (Sjödin and Svedenhag 1985; Yeung, Yeung, and Wong 2001).

Anthropometric Factors in Triathletes

In triathletes, other morphologic factors seem to be of importance. Landers et al. (2000) found that robustness, adiposity, segmental length of limbs, and skeletal muscle mass are of importance. In recent studies, successful elite triathletes are described as generally tall, average-to-light weight, and with low levels of body fat (Sleivert and Rowlands 1996). In an Ironman triathlon, starting body weight is significantly related to total finishing time and also to cycling and running time (Sharwood et al. 2002).

Other Aspects of Anthropometric Factors in Runners and Triathletes

In runners, other factors also are discussed in comparison with triathletes. In middle-and long-distance runners, length of the upper leg and thigh girth are related to performance (Tanaka and Matsuura 1982), and in marathon runners different physiological parameters can explain the variance in marathon time among elite runners (Legaz et al. 2005). In triathletes, there is no ideal or unique anthropometric profile with respect to performance (Laurenson, Fulcher, and Korkia 1993), and training parameters seem to be of more importance than anthropometric measures in the prediction of performance (Bale, Rowell, and Colley 1985; Bale et al. 1986; Billat et al. 2001; Christensen and Ruhling 1983). In marathon finishers, the longest mileage covered per training session is the best predictor for a successful completion of a marathon (Yeung et al. 2001).

And total training spent at low intensities seems to be associated with improved performance during highly intense events (Esteve-Lanao et al. 2005). But it appears that an upper limit exists in training volume, above which there are no more improvements (Sjödin and Svedenhag 1985).

Influence of Performance per Discipline

We did not find any association between anthropometric properties and total race time. An association between the times for cycling and running with total race time, however, was found (Figure 4). It seems that running performance has the most influence on race performance, whereas swimming performance seems to have the lowest influence. There might be different reasons for these observations. One explanation could be that the competitors with the best ultraendurance performance are less fatigued at the end of the competition, and because running is the last discipline in a triathlon, the less fatigued competitors show higher running performance. An ultratriathlon with a reverse sequence of disciplines might answer this question. It seems more likely to us that indeed running performance dominates success in ultratriathlons. The 2 best participants also previously had shown world class running results: One has been a European champion over a 100 km run; the other has been a member of the French national team in 24 h running. In contrast to running and cycling, excellent swimming performance needs both well-trained legs and a well-trained upper body. A well-trained upper body, however, might not be of benefit during cycling and running.

Limitations of the Present Study

In this World Championship, only 27 male athletes entered the race and 20 athletes finished. The small number of 16 official finishers who consented to participate in this study limits generalisation of the findings that the anthropometric factors evaluated in this study had no effect on race performance.

CONCLUSIONS

In summary, in an ultratriathlon requiring 11.6 km swimming, 540 km cycling, and 126.6 km running, there was no correlation between body weight, height, skinfold thicknesses, perimeter of extremities, skeletal muscle mass, and body fat and performance in 16 experienced athletes who completed the event. We presume that triathletes have a different body composition than runners, and therefore they are not comparable with runners, with regard to the influence of anthropometric factors on race performance. It is obvious from a review of the current literature that several studies have been conducted to assess the influence of anthropometry on race performance in runners performing over distances from 100 m to 10,000 m. Very little, however, is known regarding the influence of anthropometry on race performance in triathletes. Future studies should investigate the influence of anthropometric parameters on race performance in triathletes competing over short and long distances.

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