Effect of a multistage ultra-endurance triathlon on body composition: World Challenge Deca Iron Triathlon 2006

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Effect of a multistage ultra-endurance triathlon on body composition: World Challenge Deca Iron Triathlon 2006

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ABSTRACT

Objective: To investigate the effect of a multistage ultra-endurance triathlon on body composition in ultra-triathletes.

Design: Descriptive field study.

Setting: The "World Challenge Deca Iron Triathlon 2006" in Monterrey, Mexico, in which every day for 10 consecutive days athletes had to perform the distance of one Ironman triathlon.

Subjects: Eight male ultra-endurance athletes (mean (SD) age 40.6 (10.7) years, weight 76.4 (8.4) kg, height 175 (4) cm and body mass index (BMI) 24.7 (2.2) kg/m^2).

Interventions: None.

Main outcome measurements: Determination of body mass, protein mass, body fat, per cent body fat, mineral mass, total body water, intracellular water, extracellular water and lean body mass with a direct segmental multifrequency bioelectrical impedance method before the race and after each stage in order to show changes in body composition.

Results: A statistically significant decrease of body mass (−2.4 kg, p = 0.014), body fat (−5 kg, p = 0.0078) and per cent body fat (−6.4%, p = 0.0078) occurred at the end of the first day compared to values taken in the pre-race period. In contrast, at the same time, a statistically significant increase of protein mass (+0.7 kg, p = 0.035), mineral mass (+0.2 kg, p = 0.04), total body water (+1.8 litres, p = 0.042), intracellular water (+1.6 litres, p = 0.034) and lean body mass (+2.6 kg, p = 0.023) was shown. After the first day until the end of the challenge, body fat (−3 kg, p>0.05) and per cent body fat (−3.9%, p>0.05) showed a statistically significant decrease, whereas the other parameters showed no changes.

Conclusions: Athletes taking part in a multistage ultra-endurance triathlon over 10 Ironman triathlon distances in 10 consecutive days lost 3 kg of body fat; skeletal muscle mass, mineral mass and body water were unchanged.

It is well known that fat is the main energy-rich substrate for long-lasting endurance performance.[1–4] Endurance exercise leads to a reduction of adipose subcutaneous tissue as demonstrated in several field studies.[2 3 5 6]

Ultra-endurance races provide a good opportunity for studying the decrease of adipose subcutaneous tissue in long-lasting endurance performances. It appears that there is a different effect for performances with defined breaks (eg, during the night) and those without defined breaks. In long-lasting endurance performances with breaks, body mass may remain stable[7–9] or even increase[3] and body fat is reduced,[3 6] whereas skeletal muscle mass seems to be spared[4 7] or may even increase.[6] In contrast, in ultra-endurance performances for hours or even days or weeks at a time without a break, a decrease in body mass[2 10–12] has been demonstrated, in which body fat as well as skeletal muscle mass seems to decrease.[10 11 13]

In a study by Kimber *et al*, male Ironman triathletes expended in the course of one Ironman race 10 036 kcal (SD 931) and ingested 3940 kcal (SD 868), so an energy deficit of –5973 kcal (SD 1274) resulted,[14] which must be compensated for by degradation of the body's own energy stores. Up to now, a decrease in skeletal muscle mass as a result of ultra-endurance performance has been demonstrated only in case reports[10 11 13] or small series.[1] The aim of the present study was to investigate whether a larger sample of ultra-endurance triathletes would suffer only a degradation of adipose subcutaneous tissue or whether they would experience an additional loss of skeletal muscle mass following a multistage ultra-triathlon race over 10 Ironman triathlon distances in 10 consecutive days. In addition, we intended to quantify the loss of fat mass as well as the loss of skeletal muscle mass.

SUBJECTS AND METHODS

Subjects

The organiser of the World Challenge Deca Iron Triathlon 2006 contacted all participants by a separate newsletter 3 months before the race to ask them to participate in the study. All applicants gave their informed written consent. Fourteen male and 3 female caucasian ultra-triathletes started the race; 8 male athletes (mean (SD) age 40.6 (10.7) years, weight 76.4 (8.4) kg, height 175 (4) cm, body mass index (BMI) 24.7 (2.2) kg/m^2) and one female athlete (age 33 years, weight 56 kg, height 170 cm, BMI 19.38 kg/m^2) finished the race within the time limit. Only the 8 male caucasian athletes who finished were included in the study. In preparation for this race, the male athletes trained on average 24 h (SD 11) per week (between 10 and 45 h) and they had previously experienced on average 18 (between 1 and 52) extreme endurance races of 24 h or longer.

The race

The World Challenge Deca Iron Triathlon 2006 was held in November 2006 as a world premiere in ultra-triathlon. The competition took place in the city of Monterrey in the Province of Nuevo León in northern Mexico, about 230 km south of the border with the USA. The race started on 6 November 2006. Seventeen ultra-endurance athletes (14 male, 3 female) from 10 different countries and 3 continents qualified to enter the race. Every day they had to perform the distance of one Ironman triathlon of 3.8 km swimming, 180 km cycling and 42.195 km running with a time limit of 24 hours. Every morning at 09:00, the event started with swimming in the 50 m outdoor Olympic pool in the Sociedad Cuauhtemoc & Famosa Park in Monterrey, 3 km away from the cycling and running track in the Parque Niños Héroes. The pool was not heated and the water temperature was between 17°C and 21°C. Laps of 100 m were counted by personal lap counters for each athlete.

After completing the swim, the athletes changed in the transition area and, because of the enormous volume of traffic in the city, were transferred by car to the Parque Niños Héroes. A period of 30 min was allowed for transfer from the pool to the park, which was deducted from the final race time. The park was closed to traffic, completely illuminated and had a cycling track that was 95% flat, but included an inclination of 5%. The cycling consisted of 94 laps of 1.915 km each. After changing for the running course, the athletes first had to run a short lap of 703 m and then 22 laps of 1.886 km. The athletes had to climb to an altitude of 1650 m per Ironman triathlon. Drafting during cycling was strictly prohibited and controlled by the race director. Laps in the cycling and running course were counted electronically with a chip system. Athletes could be helped by their own support crew for nutrition and changes of equipment and clothes. Table 1 presents the general weather conditions and the maximum temperature each day.

During the whole race, accommodation was offered in the Sports Village of the park, about 250 m away from the race site. The athletes and their support crew had a room with bed, toilet and shower. For nutrition, the organiser offered a variety of food in a restaurant that was open 24 h.

Measurements

The evening before the start of the race and every evening after arriving at the finish line of one Ironman triathlon, body composition was measured with the InBody 3.0 Body composition analyser with direct segmental multifrequency bioelectrical impedance method (InBody 3.0, Biospace, Seoul, Korea). InBody 3.0 had a tetrapolar 8-point tactile electrode system and performed at each session 20 impedance measurements using four different frequencies (5 kHz, 50 kHz, 250 kHz, 500 kHz) at each of five segments (right arm, left arm, trunk, right leg, left leg). The subjects stood barefoot in an upright position on foot electrodes on the platform of the instrument, with the legs and thighs not touching and the arms not touching the torso. Four foot electrodes were used (two oval-shaped electrodes and two heel-shaped electrodes) and subjects were asked to grip the two palm-and-thumb electrodes (two thumb and two palm electrodes per athlete). They did this without shoes or excess clothing. The skin and electrodes were cleaned and dried before testing. The parameters of body mass, lean body mass, total body water, intracellular water, extracellular water, fat mass, per cent body fat, protein mass and mineral mass were directly determined.

Statistical analysis

The parameters were compared pairwise before the race, after the first day and after the finish. Statistical analysis was performed with the R software package (R Foundation for Statistical Computing, Vienna, Austria).[15]

The one-sample Wilcoxon signed rank test was used to check for significant changes of measured and calculated parameters before the race, after the first day and after the finish. A nonparametric method was used because the data was not ideally normally distributed. For all statistical tests, the significance level was set to 0.05. Because it was the first time a race of this kind had been held, it was necessary that this was an exploratory study of the influence of such ultra-endurance exercise. Therefore, we did not correct for multiple statistical comparisons, and our results will need to be compared with those recorded in future ultra-endurance events.

Results

Table 2 shows the average time taken to complete one Ironman triathlon per day.

The athletes had about 8−10 h of rest per day for recuperation. A statistically significant decrease of body mass (−2.4 kg, $p = 0.014$), body fat (−5 kg, $p = 0.0078$) and per cent body fat (−6.4%, $p = 0.0078$) occurred at the end of the first day compared to values taken in the pre-race period. In contrast, at the same time, a statistically significant increase of protein mass (+0.7 kg, $p = 0.035$), mineral mass (+0.2 kg, $p = 0.04$), total body water (+1.8 l, $p = 0.042$), intracellular water (+1.6 l, $p = 0.034$) and lean body mass (+2.6 kg, $p = 0.023$) was shown. After the first day until the finish, body fat (−3 kg, $p>0.05$) and per cent body fat (−3.9%, $p>0.05$) showed a statistically significant decrease, whereas the other parameters showed no changes (Table 3, fig 1).

DISCUSSION

The main finding of our investigation is that a multistage ultra-triathlon leads to a decrease in body fat, as has previously been found in ultra-endurance multistage runs.[3 6] In contrast to the findings of Raschka *et al*'s study of a multistage ultra-endurance run, skeletal muscle mass remained stable in our investigation.[6]

Table 1 Weather conditions during the race

Day	Maximum temperature each day (°C)	General weather conditions
1	28.5	Sun, little wind
2	28.8	Sun, little wind
3	30.1	Sun, little wind
4	34.9	Sun, little wind
5	35.9	Sun, little wind
6	20.3	Clouds, moderate wind
7	22.1	Clouds, little wind
8	25.7	Sun, heavy wind
9	30.9	Sun, moderate wind
10	23.9	Sun, heavy wind

Table 2 Daily race performance of the eight finishers

Day	Mean (SD) daily race performance in min
1	776 (73)
2	847 (105)
3	851 (125)
4	924 (182)
5	914 (207)
6	939 (233)
7	993 (253)
8	974 (209)
9	950 (206)
10	979 (211)

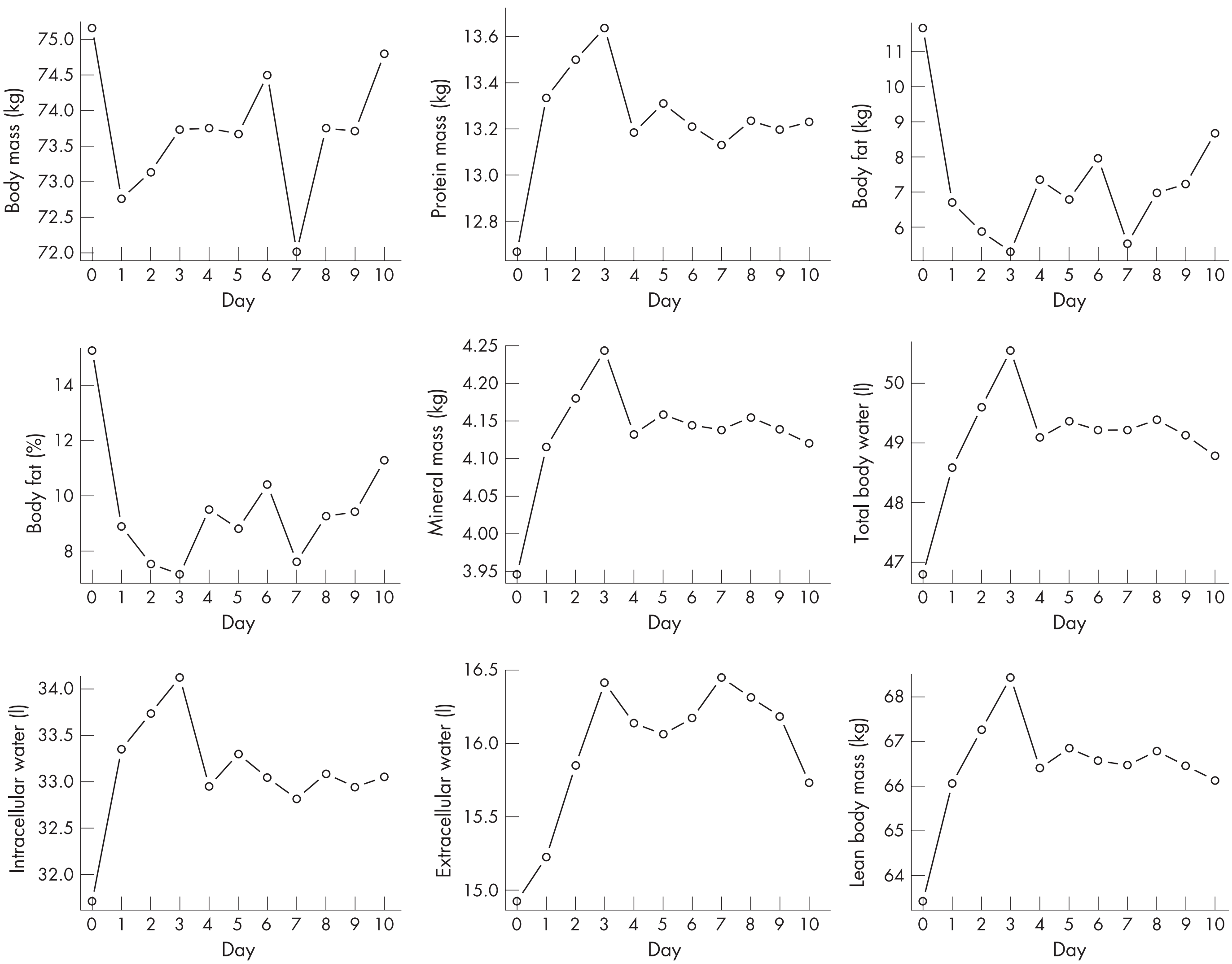

Figure 1 Time course of the measured parameters using bioelectrical impedance analysis during the race. Statistically significant changes are represented in table 3.

Change of fat mass during ultra-endurance performance

The ability to utilise fat as fuel is important in ultra-endurance athletes.[16] Subcutaneous adipose tissue is the main energy source for long-lasting endurance performance.[1–3]. In several studies, body fat has been found to decrease in ultra-endurance performances. During a run over 1000 km within 20 days, skinfold thickness and fat mass were shown to have a tendency to decrease; only the thigh skinfold increased initially and then decreased from the 4th day onwards.[3] Höchli *et al*[5]reported a decrease of 10% body fat in runners at the Paris–Dakar Foot-Race over 8000 km (600 km per runner within 30 days). Cox *et al*[17] demonstrated that fat-free mass was maintained with a concomitant decrease of body fat in dog drivers in a 1049-mile dogsled race. In the study of Helge *et al*,[2] where four male subjects crossed the Greenland icecap on cross-country skis, body mass decreased (not statistically significant) from 79.2 kg

Table 3 p Values of pairwise comparison of the data obtained from bioelectrical impedance measurements

	Before the start of the race and after day 1	After day 1 until finish	Before the start of the race until the finish
Body mass (kg)	0.014	p>0.05	p>0.05
Protein mass (kg)	0.035	p>0.05	p>0.05
Body fat (kg)	0.0078	p>0.05	0.031
% body fat (%)	0.0078	p>0.05	0.031
Mineral mass (kg)	0.03906	p>0.05	p>0.05
Total body water (litres)	0.042	p>0.05	p>0.05
Intracellular water (litres)	0.0339	p>0.05	p>0.05
Extracellular water (litres)	p>0.05	p>0.05	p>0.05
Lean body mass (kg)	0.023	p>0.05	p>0.05

Because of the exploratory nature of this study, no corrections to compensate for multiple testing effects were performed.

What is already known on this topic

Ultra-endurance performance leads to a decrease of body mass, mainly body fat.

What this study adds

- In a multistage ultra-endurance triathlon, a significant decrease of body fat occurs after the first day whereas skeletal muscle mass remains stable.
- After the first day, fat mass decreased no further.

(SD 3.9) to 73.6 kg (SD 3.4), the percentage of body fat from 22.4% (SD 1.4) to 18.2% (SD 1.1) and the lean body mass from 61.3 kg (SD 2.0) to 60.3 kg (SD 2.0). On average, their subjects had a mean mass loss of 5.7 kg (SD 0.5), of which 78% (SD 7) was fat and the remainder lean body mass. In the 1000 km run described by Raschka and Plath,[3] fat mass decreased in the male runners by 8.8 kg (−11.9%) after 500 km and at the end of the run by 7.7 kg (−10.6%). A statistically significant decrease of fat mass occurred after day 11. In contrast, in our ultra-triathletes, a statistically significant decrease of body fat had already occurred after day 1 with a decrease of 5 kg from 11.7 kg to 6.7 kg (fig 1). The lowest fat mass (5.3 kg) was shown at day 3. At the end of the race, total fat mass increased to 8.7 kg. In contrast, Raschka and Plath[3] reported a continuous decrease in fat mass. The difference in total daily distances between these studies probably explains this discrepancy. In our race and in that described by Raschka and Plath,[3] the daily distances in running were nearly the same; however, our ultra-triathletes had to run a marathon, while those in Raschka and Plath's study ran 50 km every day. In addition, in our race, 180 km of cycling was performed before the run.

Change of skeletal muscle mass during ultra-endurance performance

As shown in our investigation (fig 1), skeletal muscle mass seems to be spared in an ultra-endurance performance,[4] but in some situations, skeletal muscle mass decreases during an ultra-endurance performance.[1 10]

Skeletal muscle mass seems to decrease in ultra-endurance races without breaks, as has been shown in case reports[10 11 13] and a study with a small series of ultra-endurance athletes.[2] In contrast, in other ultra-endurance performances, skeletal muscle mass remained stable.[1 4 17] In a run over 1000 km completed within 20 days, lean body mass initially decreased from 59.3 kg to 58.9 kg by day 11 but there was a statistically significant increase to 59.9 kg by the end of the run, which was higher than the lean body mass at the start of the race (statistically significant).[6] Raschka *et al*[6] concluded from their study that the high mechanical stress of the lower extremities had a positive effect on skeletal muscle mass. In our multistage races over 10 days, protein mass and lean body mass increased after the first stage and showed no change from then on (fig 1). Obviously this race was too short to show the statistically significant increases in skeletal muscle demonstrated in the run over 20 days. Actually, there is no proof that ultra-endurance performances don't lead to an additional loss of skeletal muscle mass. In future investigations, the extent of protein catabolism should be established using biochemical methods.

Change of body mass during ultra-endurance performance

In general, non-stop endurance races over hours and days, or even weeks, result in a decrease of body mass.[2 10–12] The decrease of body mass in these ultra-endurance races ranges from 2 kg in an ultra-endurance cycling race,[10] over 3.3 kg in a Double Iron triathlon[12] to 5 kg in the Race across America[11] and 5.7 kg after skiing across the Greenland icecap.[2] Our athletes showed a statistically non-significant loss of 1.7 kg (−2.3%) body mass after 10 Ironman triathlons (fig 1), which was less than the loss of body mass in one Ironman triathlon, where body mass decreased significantly during the race.[18–20] In one Ironman triathlon, body mass declined by 2.3 kg[18] to 2.5 kg.[21] A loss of 2.5 kg body mass corresponds to a mean percentage loss in body mass of 3%.[22] The statistically non-significant decrease of 1.7 kg body mass in our ultra-endurance triathletes is equal to the loss of 1.75 kg body mass of the athletes in the ultra-endurance run over 1000 km within 20 days, described by Raschka and Plath.[3] In their investigation, there was a statistically significant decrease in body mass after day 8 until day 11, which then remained stable until the finish. It is likely that our race was too short compared to that studied by Raschka and Plath in order to show a statistically significant decrease of body mass.[3]

Is bioelectrical impedance analysis (BIA) a reliable and valid method?

In our study, we used the BIA method whereas Raschka *et al*[6]used the anthropometric measurements method in their study of a multistage ultra-endurance run. BIA has been tested for its reliability and validity compared to other methods such as near-infrared interactance (NIR), skinfold measurements and dual energy *X*-ray absorptiometry (DEXA).[23–25] When BIA is compared with the skinfold method and near-infrared interactance, it appears to be more accurate in a wide range of different individuals.[26]

Both the skinfold and BIA methods seem to be sufficiently accurate on the narrow sample of subjects on which they were developed[26] and both methods show a fairly good correlation with DEXA as a reference method.[27] BIA seems to be a valid field method for athletic status[25] but in two studies, the authors concluded that the body composition parameters may be better estimated by the skinfold method.[28 29] One problem is that fluid changes often are interpreted as changes in fat mass[30] where the skinfold method provides the lowest body fat mass when DEXA, BIA and the skinfold method are compared.[31]

CONCLUSIONS

Athletes taking part in a multistage ultra-endurance triathlon over 10 Ironman triathlon distances in 10 consecutive days lost 3 kg of body fat; skeletal muscle mass, mineral mass and body water were unchanged. For future studies of multistage races, we recommend determining skeletal muscle mass and fat mass using two different methods such as BIA and the skinfold method, and measuring haematological and urine parameters in order to quantify fluid metabolism.

Competing interests: None declared.

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Commentary

The effect of an ultra-triathlon (10 Ironman triathlon distances in 10 days) on eight athletes (mean age 40.6 years, mean BMI 24.7 kg/m^2) taking part in the World Challenge Deca Iron Triathlon 2006 (Monterrey, Mexico) was examined using direct multifrequency bioelectrical impedance analysis. The athletes lost 3 kg of body fat, whereas muscle mass, mineral mass and body water did not change. The loss of 1.75 kg body mass is equal to the loss of 1.75 kg body mass in an ultra-endurance run over 1000 km within 20 days as described earlier in 1992. In this race the loss of body mass was measured anthropometrically.

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