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# Effect of a multistage ultra-endurance triathlon on body composition: world challenge deca iron triathlon 2006

## 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<sup>2</sup>). **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.

## **A multi-stage ultra-endurance triathlon leads to a decrease of body fat but not of skeletal muscle mass – the World Challenge Deca Iron 2006**

**Keywords:** endurance performance – anthropometry – percent body fat – bioelectrical impedance analysis

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## Abstract

**Objective:** To investigate the effect of a multi-stage ultra-endurance triathlon on body composition in ultra-triathletes. **Design:** Descriptive field study. **Setting:** The “World Challenge Deca Iron Triathlon 2006” in Monterrey, Mexico, where, every day, athletes had to perform the distance of one Ironman triathlon within 10 consecutive days. **Subjects:** Eight male ultra-endurance athletes (mean  $\pm$  SD, 40.6  $\pm$  10.7 years, 76.4  $\pm$  8.4 kg, 175  $\pm$  4 cm, BMI 24.7  $\pm$  2.2 kg/m<sup>2</sup>). **Interventions:** None. **Main Outcome Measurements:** Determination of body mass, protein mass, body fat, percent body fat, mineral mass, total body water, intracellular water, extracellular water and lean body mass with a direct segmental multi-frequency bioelectrical impedance method before the race and after each stage in order to show changes in body composition. **Results:** Between pre race and after the first day, a statistically significant decrease of body mass (- 2.4 kg, p=0.014), body fat (- 5 kg, p=0.0078) and percent body fat (- 6.4 %, p=0.0078) occurred. 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 (- 3kg, p>0.05) and percent body fat (- 3.9 %, p>0.05) showed a statistically significant decrease, whereas the other parameters showed no changes. **Conclusions:** Athletes at a multi-stage ultra-endurance triathlon over 10 times an Ironman triathlon within 10 days lost 3 kg of body fat whereas skeletal muscle mass, mineral mass and body water did not change.

## Introduction

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 shown in several field studies.[2, 3, 5, 6]

Ultra-endurance races are a good opportunity to study the decrease of adipose subcutaneous tissue in long lasting endurance performances, but there seems to be a difference between performances with defined breaks - for example during the night - and non-stop performances without defined breaks.

In long lasting endurance performances with breaks, body mass may remain stable [7-9] or even increase [3] and body fat will be reduced [3, 6], whereas skeletal muscle mass seems to be spared [4, 7] or even increased [6].

In contrast, in ultra-endurance performances for hours or even days or weeks without a break, a decrease of body mass [2, 10-12] has been demonstrated, whereas body fat as well as skeletal muscle mass seems to decrease [10, 11, 13].

In the study of Kimber *et al.* with male Ironman triathletes, they expended, during one Ironman race,  $10,036 \pm 931$  kcal and ingested  $3,940 \pm 868$  kcal, so an energy deficit of  $-5,973 \pm 1,274$  kcal resulted.[14] This deficit must be covered by degradation of body-own energy stores. Up to now, the decrease of skeletal muscle mass in ultra-endurance performance has been demonstrated only in case reports [10, 11, 13] or small series [1].

In this present study we wanted to investigate with a greater sample of ultra-endurance triathletes at a multi-stage ultra-triathlon race over the distance of 10 times an Ironman triathlon within 10 consecutive days, whether ultra-endurance triathletes would suffer only a degradation of adipose subcutaneous tissue, or whether they would experience an additional loss of skeletal muscle mass. 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 of the race by a separate newsletter, 3 months before the race, in which they were asked to participate in the study. They all gave their informed written consent. Fourteen male and 3 female ultra-triathletes started in the race, 8 male athletes (mean  $\pm$  SD,  $40.6 \pm 10.7$  years,  $76.4 \pm 8.4$  kg,  $175 \pm 4$  cm, BMI  $24.7 \pm 2.2$  kg/m<sup>2</sup>) as well as one female athlete finished the race successfully within the time limit. We included for our investigation only the 8 male Caucasian athletes. Average training of the male athletes in the preparation for this race was  $24 \pm 11$  hours per week varying from 10 to 45 hours and they had an average experience of 18 (one to 52) extreme endurance races of 24 hours and longer prior to the start of this race.

### *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<sup>th</sup> November. Seventeen ultra-endurance athletes (14 male, 3 female) from 10 different countries and 3 continents were qualified and entered the race. They had to perform, every day, 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 a.m., swimming started in the 50 m outdoor Olympic pool in the Sociedad Cuauhtemoc & Famosa Park in Monterrey, 3 kilometres away from the cycling and running track in the Parque Niños Héroes. The pool was not heated and the water temperature was between 17° and 21° Celsius. Laps of 100 m were counted by personal lap counters for each athlete. After having completed the swimming part, 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. Every athlete was allowed to have 30 minutes for the transfer from the pool to the park. The time was deducted from the final race time. The park is closed to traffic, completely illuminated and has a cycling track which is 95% flat, but includes an inclination of 5%. The cycling consisted of 94 laps of 1.915 km each. After changing for the running part, the athletes first had to run a short lap of 703 metres and then 22 laps of 1.886 km. The athletes had to climb an altitude of 1,650 m per Ironman triathlon. Drafting during the cycling was strictly prohibited and controlled by the race director. Laps in the cycling and running course were counted electronically with a chip-system. The athletes were helped by their own support crew for nutrition and changes of equipment and clothes. The general weather conditions and the highest temperature during the day are represented in **Table 1**.

Day	Highest temperature during the day [°Celsius]	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 1:** Weather conditions during the race

During the whole race, accommodation was offered in the Sports Village of the park, about 250 metres 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 which was open 24 hours.

### ***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 analyzer with direct segmental multi-frequency bioelectrical impedance method (InBody 3.0, Biospace, Seoul, Korea). InBody 3.0 has a tetrapolar 8-point tactile electrode system performing at each session 20 impedance measurements by using 4 different frequencies ( $5^{\text{kHz}}$ ,  $50^{\text{kHz}}$ ,  $250^{\text{kHz}}$ ,  $500^{\text{kHz}}$ ) at each 5 segments (right arm, left arm, trunk, right leg, left leg). The subjects were standing in an upright position, barefoot, on foot-electrodes on the platform of the instrument, with the legs and thighs not touching, and the arms not touching the torso. The subjects stood on the four foot-electrodes: 2 oval shaped electrodes and 2 heel shaped electrodes, and gripped the 2 palm-and-thumb electrodes in order to yield 2 thumb electrodes and 2 palm electrodes. They did this without shoes or excess clothing. The skin and the electrodes were precleaned and dried. The parameters of body mass, lean body mass, total body water, intracellular water, extracellular water, fat mass, percent 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 race.

Statistical analysis was performed with the R software package.[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. It was the first time this kind of race was held therefore our study had to be an exploratory investigation to examine the influence of ultra endurance exercise of this kind. Therefore, we did not correct for multiple statistical comparisons. As a consequence, our results will ideally need checking in future ultra events.

## Results

The average race time for one Ironman per day is represented in **Table 2**.

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

**Table 2:** Daily race performance of the 8 successful finishers. Results are presented as mean values and standard deviation (SD)

The athletes had about 8 to 10 hours of rest per day for regeneration. Between pre race and after the first day, a statistically significant decrease of body mass (- 2.4 kg,  $p=0.014$ ), body fat (- 5 kg,  $p=0.0078$ ) and percent body fat (- 6.4 %,  $p=0.0078$ ) occurred. 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 (- 3kg,  $p>0.05$ ) and percent body fat (- 3.9 %,  $p>0.05$ ) showed a statistically significant decrease, whereas the other parameters showed no changes (**Table 3 and figure 1**).

	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 [l]	0.042	$p>0.05$	$p>0.05$
intracellular water [l]	0.0339	$p>0.05$	$p>0.05$
extracellular water [l]	$p>0.05$	$p>0.05$	$p>0.05$
lean body mass [kg]	0.023	$p>0.05$	$p>0.05$

**Table 3:** P-values of pairwise comparison of the data obtained from the bioelectrical impedance measurements. Because of the exploratory character of this study, no corrections to compensate for multiple testing effects were performed.

## Discussion

The main finding of our investigation is that a multi-stage ultra-triathlon leads to a decrease of body fat, as previously found in ultra-endurance multi-stage runs.[3, 6]. In contrast to the findings of Raschka *et al.* during a multi-stage ultra-endurance run, skeletal muscle mass remained stable in this race.[6]

### *Change of fat mass during ultra-endurance performance*

The ability to utilise fat as fuel is important in ultra-endurance athletes.[16] Adipose subcutaneous tissue is the main energy source for long lasting endurance performance [1-3], and is also shown in our study (**Figure 1**). In several studies, body fat decreases in ultra-endurance performances. In a run over 1,000 km within 20 days, all skin fold thicknesses and the fat mass showed a falling tendency; only the thigh skin fold initially grew, and then came down from the 4<sup>th</sup> day onwards [3], and Höchli *et al.* could show, at the Paris-Dakar Foot-Race over 8,000 km (600 km per runner within 30 days), a decrease of 10% body fat in their runners.[5] Cox *et al.* demonstrated, in a 1,049-mile sled dog race that fat-free mass was maintained with a concomitant decrease of body fat.[17] In the study of Helge *et al.*, where 4 male subjects crossed the Greenland icecap on cross-country skis, body mass decreased statistically non significantly from  $79.2 \pm 3.9$  kg to  $73.6 \pm 3.4$  kg, the percentage of body fat from  $22.4 \pm 1.4\%$  to  $18.2 \pm 1.1\%$  and the lean body mass from  $61.3 \pm 2.0$  kg to  $60.3 \pm 2.0$  kg. On average, their subjects had a mean mass loss of  $5.7 \pm 0.5$  kg, of which  $78 \pm 7\%$  was fat and the remainder lean body mass.[2] In the 1,000 km run described by Raschka & Plath, 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%).[3] A statistically significant decrease of fat mass occurred after day 11. In contrast, in our ultra-triathletes, a statistically significant decrease of body fat already occurred after day 1 with a decrease of 5 kg from 11.7 kg to 6.7 kg (**Figure 1**). The lowest fat mass was shown at day 3 with 5.3 kg. At the end of the race, total fat mass increased to 8.7 kg. In contrast, in the race described by Raschka & Plath, fat mass decreased continuously.[3] Probably the total daily distances were of importance so that difference in decrease of fat mass occurred. In our race and in the race described by Raschka & Plath, the daily distances in running were nearly the same.[3] Our ultra-triathletes had to run a marathon, the runners in the multi-day run did 50 km every day. In addition in our race, 180 km of cycling had to be performed before the run.

### *Change of skeletal muscle mass during ultra-endurance performance*

As shown in our investigation (**Figure 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 it has been shown in case reports [10, 11, 13] or a study with a small series [2] of ultra-endurance athletes. In contrast, in other ultra-endurance performances, skeletal muscle mass remained stable.[1, 4, 17] In a run over 1,000 km within 20 days, lean body mass initially decreased only from 59.3 kg to 58.9 kg on day 11 and increased then statistically significantly to the end of the run to 59.9 kg, which was statistically significantly higher than the lean body mass at the start.[6] Raschka *et al.* concluded from their study that the high mechanical stress of the lower extremities had a positive effect on skeletal muscle mass.[6] Compared with our multi-stage races lasting for 10 days, protein mass and lean body mass increased after the first stage and showed no changes from then on (**Figure 1**). Obviously this race over 10 days was too short to show statistically significant increases in skeletal muscle mass as the run over 20 days showed. **Actually, there is no proof that ultra-endurance doesn't lead to an additional loss of skeletal muscle mass. In further investigations, the extent of protein catabolism should be clarified by using biochemical methods.**

### *Change of body mass during ultra-endurance performance*

In general, non-stop endurance races over hours and days, or even weeks, results in a decrease of body mass.[2, 10, 11, 12] The decrease of body mass in these ultra races lies between 2 kg in an ultra 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 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 (**Figure 1**), therefore less than the decrease of body mass in one Ironman triathlon, where body mass decreases significantly during the race.[18-20] In one Ironman triathlon, body mass declines 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 1,000 km within 20 days, described by Raschka & Plath.[3] In their investigation, body mass decreased statistically significantly after day 8 until day 11 and then remained stable until the finish. Probably our race was too short compared to the results of Raschka *et al.* in order to show a statistically significant decrease of body mass.[3]

### ***Is the method of bioelectrical impedance analysis (BIA) a reliable and valid method?***

In our study, we used the bioelectrical impedance analysis method whereas Raschka *et al.* used the anthropometric measurements method in their study at a multi-stage ultra-endurance run.[6] **The method of BIA has been tested for its reliability and validity compared to other methods such as near-infrared interactance (NIR), skin fold measurements and DEXA.[23-25] When BIA is compared with skin fold method and NIR, BIA appears to be more accurate on a wide range of different individuals.[26].**

**Both 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 2 studies, the authors concluded that the body composition parameters may be better estimated by the skin fold method.[28, 29] One problem is that fluid changes often are interpreted as fat weight [30] where the skin fold method provides the lowest body fat mass when DEXA, BIA and the skin fold method are compared.[31]**

### **Conclusions**

Athletes at a multi-stage ultra-endurance triathlon over 10 times an Ironman triathlon within 10 days lost 3 kg of body fat whereas skeletal muscle mass, mineral mass and body water showed no changes. **For further multi-stage races, we recommend determining skeletal muscle mass and fat mass with two different methods such as BIA and the skin fold method and to measure additionally haematologic and urine parameters in order to quantify fluid metabolism.**

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**Figure 1:** Time course of the measured parameters with bioelectrical impedance analysis during the race. Statistically significant changes are represented in Table 3.

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**What is already known on this topic:**

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

**What this study adds:**

In a multi-stage 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 did not decrease anymore.

