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PREDICTORS OF RACE TIME IN MALE IRONMAN TRIATHLETES: PHYSICAL CHARACTERISTICS, TRAINING OR PRERACE EXPERIENCE?[1,2]

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Summary.- To assess whether physical characteristics, training, or prerace experience were related to performance in recreational male Ironman triathletes using bi- and multivariate analysis. Eighty-three male recreational triathletes, mean 41.5 yr. (*SD*=8.9) years, 1.80 m (*SD*=0.06) body height, 77.3 kg (*SD*=8.9) body mass and a Body Mass Index of 23.7 kg/m^2 (*SD*=2.1) at the 2009 IRONMAN SWITZERLAND volunteered to participate in the study. Speed in running during training, personal best marathon time, and personal best time in an Olympic distance triathlon were related to the Ironman race time. These three variables explained 64 % of the Ironman race time. Personal best marathon time was significantly and positively related to the run split time in the Ironman race. It was concluded that faster running while training and both a fast personal best time in marathon and in an Olympic distance triathlon were associated with a fast Ironman race time.

Triathlon includes swimming, cycling, and running. Triathlon races are classically performed over the short (Olympic) distance of 1.5 km swimming, 40 km cycling and 10 km running (Bernard, Sultana, Lepers, Hausswirth, & Brisswalter, 2010) and the Ironman distance of 3.8 km swimming, 180 km cycling and 42.2 km running (Lepers, 2008). The Ironman distance is the most popular long-distance triathlon. Since the first event, held in 1978 in Hawaii, thousands of triathletes compete in Ironman races every year to qualify for the Ironman World Championship in Hawaii, where more than 1,700 triathletes start (Lepers, 2008). Competing and finishing an Ironman triathlon requires an athlete to train and race in three different disciplines where, apart from the physiological variables, the variables of physical characteristics might also be associated with performance.

There is little data about the association between physical characteristics and race performance for Ironman triathletes. For short-distance triathletes, Sleivert and Rowlands (1996) described elite triathletes as tall, of average to light weight, and with low body fat. Landers, Blanksby, Ackland, and Smith (2000) showed that low body fat was important for an overall race time and split times. A comparison of the height, weight, and percent body fat of Ironman triathletes with those of elite athletes from the sports of swimming, cycling, and running showed the physique of triathletes to be most similar to that of cyclists (O'Toole, 1989). However, to date, researchers do not seem to have assigned a potential association of physical characteristics with race time to Ironman triathletes.

Apart from physical characteristics, training volume and intensity seem to influence race performance in triathletes. For Ironman triathletes, training distances appear to be more important in race preparation than training paces (O'Toole, Hiller, Crosby, & Douglas, 1987). In addition to training, prerace experience is also associated with an Ironman race time. Gulbin and Gaffney (1999) reported that previous best performances in an Olympic distance triathlon, coupled with weekly cycling distances and longest training ride, could partially predict an overall Ironman race performance.

It is important to investigate, using one sample group of athletes, whether physical characteristics, training, or prerace experience were related to an Ironman race time. The aim of this study was to investigate which variable of physical characteristics, training or pre race experience is related to performance in an Ironman triathlon using one single sample group of athletes. Based on the existing literature we hypothesized that body fat, cycling volume, and personal best time in an Olympic distance triathlon would be related to an Ironman race time. Possibly one single variable such as personal best time would predict an Ironman race performance as has been described for ultra-marathoners in a 24-h ultra-run (Knechtle, Wirth, Knechtle, Zimmermann, & Kohler, 2009).

METHOD

Participants

All male athletes in the IRONMAN SWITZERLAND 2009 race were informed about the investigation, via two newsletters sent by the organizer, plus separate information shown on the race website about the planned investigation. Interested athletes who volunteered for the study were informed of the procedures and gave their informed consent prior to the investigation. The investigation was approved by the Ethical Committee of St. Gallen, Switzerland. A total of 98 non-professional male Ironman triathletes volunteered to take part in the investigation; 83 participants completed the race within the time limit.

The Race

A cross-sectional, observational field study was performed at the IRONMAN SWITZERLAND held on 12 July 2009 in the heart of the City of Zurich, Switzerland. A total of 2,534 male Ironman triathletes from 49 countries started in the morning at 07:00 a.m. At the beginning the air temperature was 14° Celsius and the water in Lake Zurich was 20° Celsius. Due to the low water temperature wet suits were allowed. At the start, the sky was clear and became cloudy slowly during the afternoon and evening. The highest temperature, 22° Celsius, was reached in the afternoon. The athletes had to swim two laps in the lake to cover the 3.8 km distance and then had to cycle two laps of 90 km each, followed by running four laps of 10.5 km each. In the cycling part, the highest point to climb from Zurich (400 meters above sea level) was the ‘Forch’ (700 meters above sea level), while the running course was completely flat in the City of Zurich. Nutrition was provided for the cycling and running courses by the organizers. They offered bananas, energy bars, energy gels, and carbohydrate drinks as well as caffeinated drinks and water on the cycling course. On the running course, in addition to the aforementioned nutrition, different fresh fruits, dried fruits, nuts, chips, salt bars, and soup were provided.

Measurements and Calculations

Upon inscription to the study, the athletes began a comprehensive training diary, recording each training unit in swimming, cycling, and running, including the distance (km), duration (h), and speed (km/h) for each training session and discipline until the start of the race. They reported their number of finished Olympic distance triathlons, marathons, and Ironman triathlons including their own personal best time in each discipline, where personal best time was defined as the best time ever achieved. The afternoon before the start of the race body mass, body height, and thicknesses of skin-folds at eight sites were measured. With this data, Body Mass Index, and percent body fat, using an anthropometric method, were calculated. 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. Skin-fold data was obtained using a skin-fold caliper (GPM-Hautfaltenmessgerät, Siber & Hegner, Zurich, Switzerland) and recorded to the nearest 0.2 mm. One trained investigator took all the measurements as intertester variability is a major source of error in skin-fold measurements. An intratester reliability check was conducted on 27 male and 11 female runners prior to testing. Intra-class correlation (ICC) within the two judges was excellent for both men and women for all anatomical measurement sites (ICC>0.9) (Knechtle, Joleska, Wirth, Knechtle, Rosemann, & Senn, 2010). The skin-fold measurements were taken once, on the right side of the body, for all seven skin-folds of chest, mid-axilla, triceps, subscapular, abdomen, suprailiac, and thigh and the procedure was repeated twice more 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 standardized to ensure reliability. According to Becque, Katch, and Moffat (1986), readings were performed 4 sec after applying the caliper. Percent body fat was calculated using the anthropometric formula according to Ball, Altena, and Swan (2004), with percent body fat = $0.465 + 0.180(\Sigma 7SF) - 0.0002406(\Sigma 7SF)^2 + 0.0661(age)$, where $\Sigma 7SF$ = sum of skin-fold thickness of chest, mid-axilla, triceps, subscapular, abdomen, suprailiac, and thigh.

Statistical Analyses

Data are presented as means and standard deviation (*SD*). In a first step, body height, body mass, percent body fat, weekly cycling volume, and personal best time in an Olympic distance triathlon were included in a multiple linear regression model with race time as the dependent variable (Model 1). In a second step, all volumes and speeds in training for all three sub-disciplines were added to the model (Model 2). In a third step, personal best time in a marathon was added (Model 3). A probability value of less than .05 was accepted as significant.

RESULTS

In Table 1, the anthropometric data, training, and pre race experience of the athletes are presented. The athletes completed the 3.8-km swim, 180-km bike and 42.195-km run within 11:15 h:min, 689 (*SD*=79) min, respectively. Expressed as a percentage of the course record (8:12 h:min), the athletes finished with 139 % (*SD*=15). The swim speed of 3.0 (*SD*=0.4) km/h and the cycle speed of 31.5 (*SD*=3.1) km/h during the race were significantly faster than the speed in either discipline during training ($p < .001$). For running, the speed of 10.1 (1.5) km/h during the race was significantly slower compared to the speed during training ($p < .0001$).

In Model 1 (Table 2) showing body height, body mass, percent body fat, personal best time in an Olympic distance triathlon, and weekly cycling kilometers as predictor variables, body mass, percent body fat and personal best time in an Olympic distance triathlon were related to race time. The three variables explained 55 % of the Ironman race time. When all the volumes and speeds in training for all three sub-disciplines were added into Model 2 (Table 3), body mass, percent body fat and personal best time in an Olympic distance triathlon were related to race time. The three variables explained 61 % of the Ironman race time. When the personal best time in a marathon was added into Model 3 (Table 4), speed in running during training (Fig. 1), personal best marathon time (Fig. 2), and personal best time in an Olympic distance triathlon (Fig. 3) were related to the Ironman race time. These three variables explained 64 % of the Ironman race time. Personal best marathon time was significantly and positively related to the run split time in the Ironman race (Fig. 4).

DISCUSSION

The aim of the study was to investigate, in one sample group of athletes, whether prerace experience, physical characteristics or training were related to performance in an Ironman triathlon. Based on the literature, it was hypothesized that body fat, cycling volume, and personal best time in an Olympic distance triathlon would be related to the Ironman race time. Alternatively, there is an argument about whether one single variable, such as personal best time, would predict race time as has been described for ultra-marathoners (Knechtle, *et al.,* 2009). In contrast to the hypothesis, the three variables, of speed in running during training, and the personal best time in both an Olympic distance triathlon and a marathon, were related to race time and could explain 64 % of the Ironman race time.

In the first model, including the variables of body mass, percent body fat, and personal best time in an Olympic distance triathlon were related to race time and coefficient of determination (R^2) of the model was 55 %. By adding all the volumes and speeds in training for all three sub-disciplines into Model 2, R^2 increased to 61 %, and the same three variables were related to race time. When the personal best marathon time was added, R^2 increased to 64 % in Model 3, where speed in running during training and the personal best time in both a marathon and an Olympic distance triathlon were related to the Ironman race time. These findings are in line with recent findings for Triple Iron triathletes, where running performance was related to race time, but not physical characteristics (Knechtle, Duff, Amtmann, & Kohler, 2007; Knechtle, & Kohler, 2009).

Personal best time in an Olympic distance triathlon was significant in all three models. It was assumed that, according to Gulbin and Gaffney (1999), a fast personal best time in a race shorter than the actual race would be related to race performance in a longer race. Also in a recent study of ultra-runners, a personal best marathon time was the single predictor variable for the distance covered during 24 hours of running (Knechtle, Wirth, Knechtle, Zimmermann, & Kohler, 2009). In Triple Iron triathletes, a personal best Ironman race time was positively and highly significantly related to a Triple Iron race time, but not anthropometric or training characteristics (Knechtle, Knechtle, Rosemann, & Senn, 2010).

Body mass was the only anthropometric variable related to race time in two of the three models. Our participants finished within 11.15 h:min, slightly faster than those subjects in the study of Gulbin and Gaffney (1999) who completed the Ironman within 11.76 h. Our participants were about the same weight as those athletes with 70.8 kg (*SD*=7.1) however, those authors were not investigating a potential association of physical characteristics with race time. Percent body fat was related to race time in Models 1 and 2, but not in Model 3. It was assumed that low body mass was more important than low body fat, presumably because of the hilly cycling course.

In these participants, a significant association of running speed during training with the Ironman race time was found, whereas Gulbin and Gaffney (1999) described an association with weekly cycling distances. The weekly cycling distance was also included; however, this variable was not associated with race time in all three models. One reason for these differences might be in the training of the athletes. The athletes in the study of Gulbin and Gaffney (1999) swam 8.8 km (*SD*=4.3) per week, cycled 270 km (*SD*=107) and ran 58.2 km (*SD*=21.9). Compared with our participants, the mean was higher for their athletes. Considering the speed, the athletes from Gulbin and Gaffney (1999) swam at 3.3 km/h, cycled at 31.8 km/h and ran at 13.2 km/h during training. These mean values were higher than the values of our participants; however, the race time of our participants was slightly faster than their race times. Presumably the higher cycling volume and the higher intensity in cycle training was the reason for the different findings.

This study was limited as nutritional intake was not assessed in the current study. It is very likely that race nutrition will influence the overall race time in Ironman events (Kimber, Ross, Mason, & Speedy, 2002). In further studies, nutrition should also be considered.

CONCLUSION

It was not possible to find a single predictor variable for Ironman triathletes as has been described for ultra-marathoners. Training (intensity in running) and prerace experience (personal best time in both an Olympic distance triathlon and a marathon) were all associated with race time in an Ironman triathlon. One may conclude that high speed in running during training and a fast personal best time in both an Olympic distance triathlon and a marathon were all associated with a fast Ironman race time.

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TABLE 1

Anthropometry, Training and Prerace Experience of the Participants (*n*=83)

Measures	***M***	***SD***
Body mass, kg	77.3	8.9
Body height, m	1.80	0.6
Body mass index, kg/m^2	23.7	2.1
Percent body fat, %	15.7	4.6
Weekly training hours, h	14.7	5.9
Weekly swimming kilometers, km	6.0	2.9
Speed in swimming during training, km/h	2.8	0.6
Weekly cycling kilometers, km	189.6	70.2
Speed in cycling during training, km/h	28.1	2.9
Weekly running kilometers, km	44.8	17.6
Speed in running during training, km/h	11.2	1.2
Number of finished Olympic triathlons, *n*=61	13.4	13.6
Personal best time in an Olympic triathlon, min	139	14
Number of finished marathons, *n*=62	12.2	21.1
Personal best time in a marathon, min	200	26
Number of finished Ironman triathlons, *n*=64	4.9	5.8
Personal best time in an Ironman triathlon, min	680	78

TABLE 2

Multiple Linear Regression Analysis with Race Time as the Dependent Variable for Ironman Triathletes (*n*=67).

Measures	***ß***	***SE***	***p***
Body height	- 121	133.6	.36
Body mass	2.5	1.0	.01
Percent body fat	4.3	1.6	.01
Weekly cycling kilometers	0.02	0.10	.78
Personal best time in an Olympic triathlon	2.5	0.5	.00

Note.- Coefficient of determination (R^2) of Model 1 was 55%.

TABLE 3

Multiple Linear Regression Analysis with Race Time as the Dependent Variable for Ironman Triathletes (*n*=67).

Measures	***ß***	***SE***	***p***
Body height	- 104.5	134.4	.44
Body mass	2.53	1.08	.02
Percent body fat	4.62	1.6	.00
Weekly swimming kilometers	- 0.35	2.8	.90
Speed in swimming during training	- 23.7	12.8	.06
Weekly cycling kilometers	0.16	0.14	.24
Speed in cycling during training	- 5.11	2.89	.08
Weekly running kilometers	0.18	0.47	.69
Speed in running during training	11.2	6.7	.10
Personal best time in an Olympic triathlon	2.65	0.53	.00

Note.- Coefficient of determination (R^2) of Model 2 was 61%.

TABLE 4

Multiple Linear Regression Analysis with Race Time as the Dependent Variable for Ironman Triathletes (*n*=67).

Measures	***ß***	***SE***	***p***
Body height	- 180.7	158.8	.26
Body mass	2.4	1.27	.07
Percent body fat	3.4	1.9	.07
Weekly swimming kilometers	0.6	3.4	.86
Speed in swimming during training	- 36.8	16.2	.28
Weekly cycling kilometers	0.13	0.17	.43
Speed in cycling during training	- 6.9	3.8	.07
Weekly running kilometers	0.6	0.6	.29
Speed in running during training	22.4	8.5	.01
Personal best time in a marathon	0.9	0.4	.04
Personal best time in an Olympic triathlon	2.5	0.7	.00

Note.- Coefficient of determination (R^2) of Model 3 was 64%.

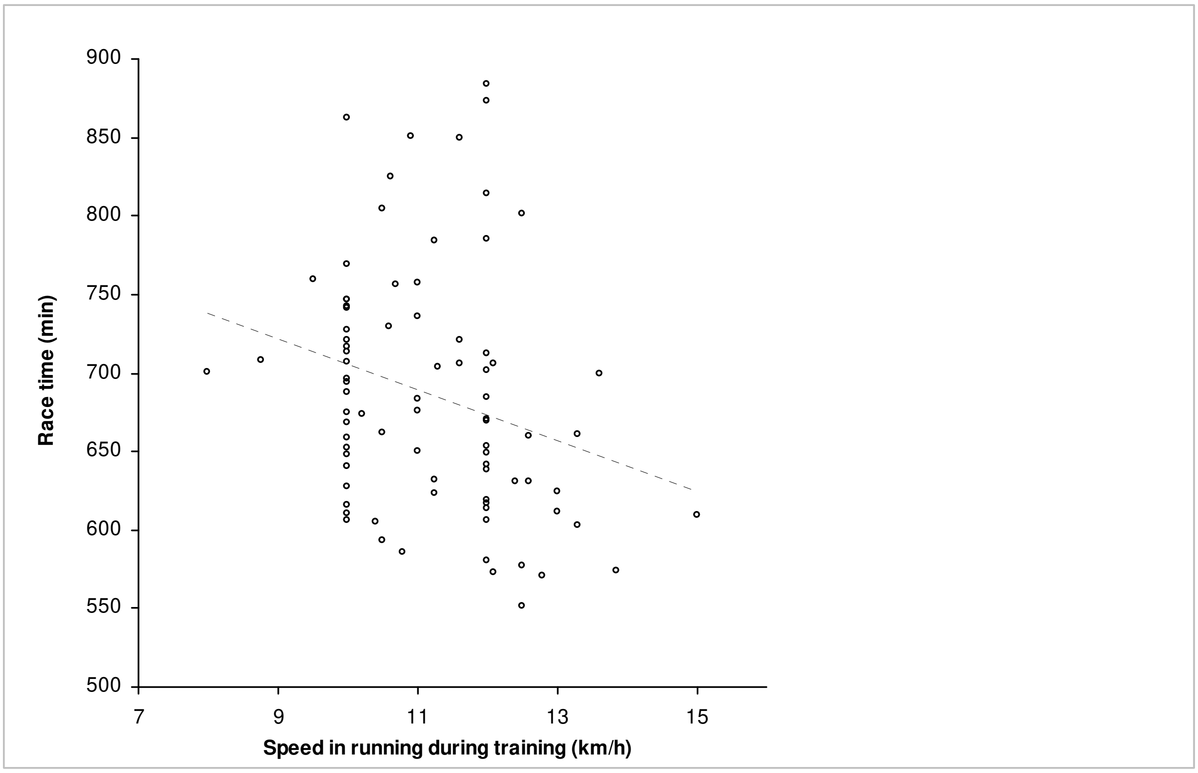

Fig. 1. Running speed during training was related to race time in the Ironman triathletes (n=83) with r = -.26 (95% CI - .45 to - .05) (p < .05).

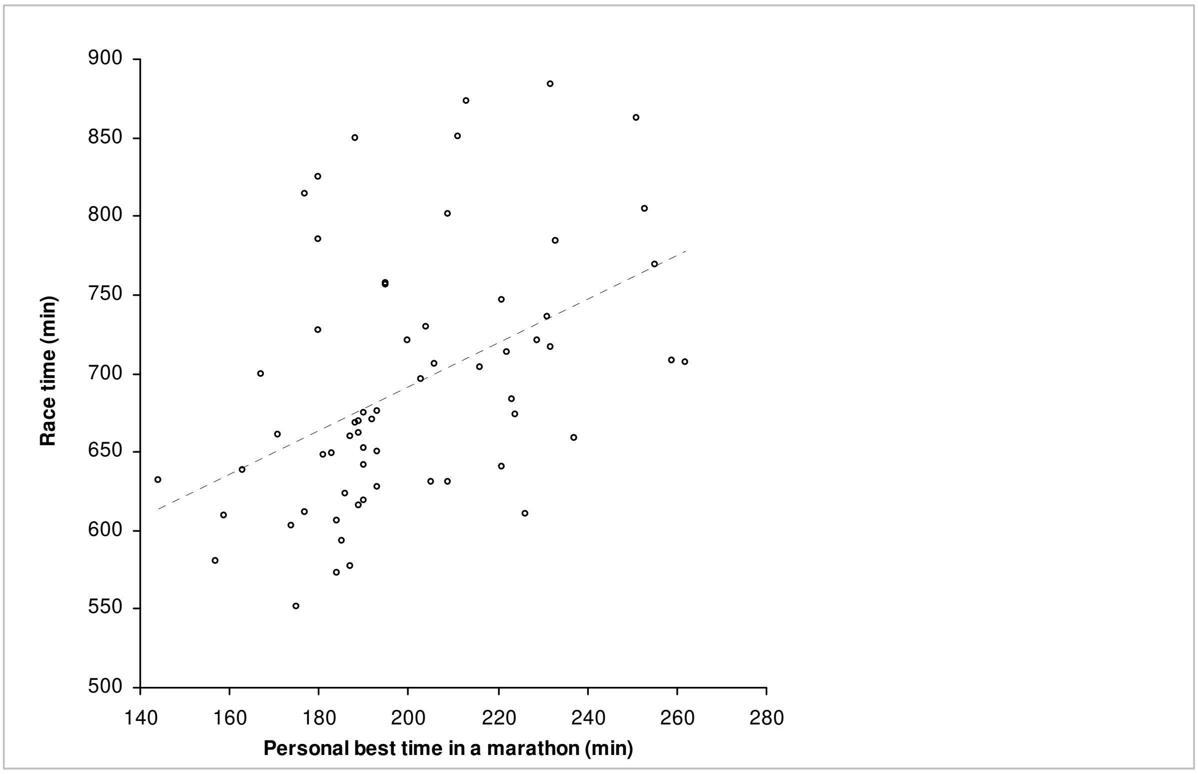

Fig. 2. Personal best marathon time was related to race time in the Ironman triathletes (*n*=63) with $r = .45$ (95% CI .23 to .63) ($p < .05$).

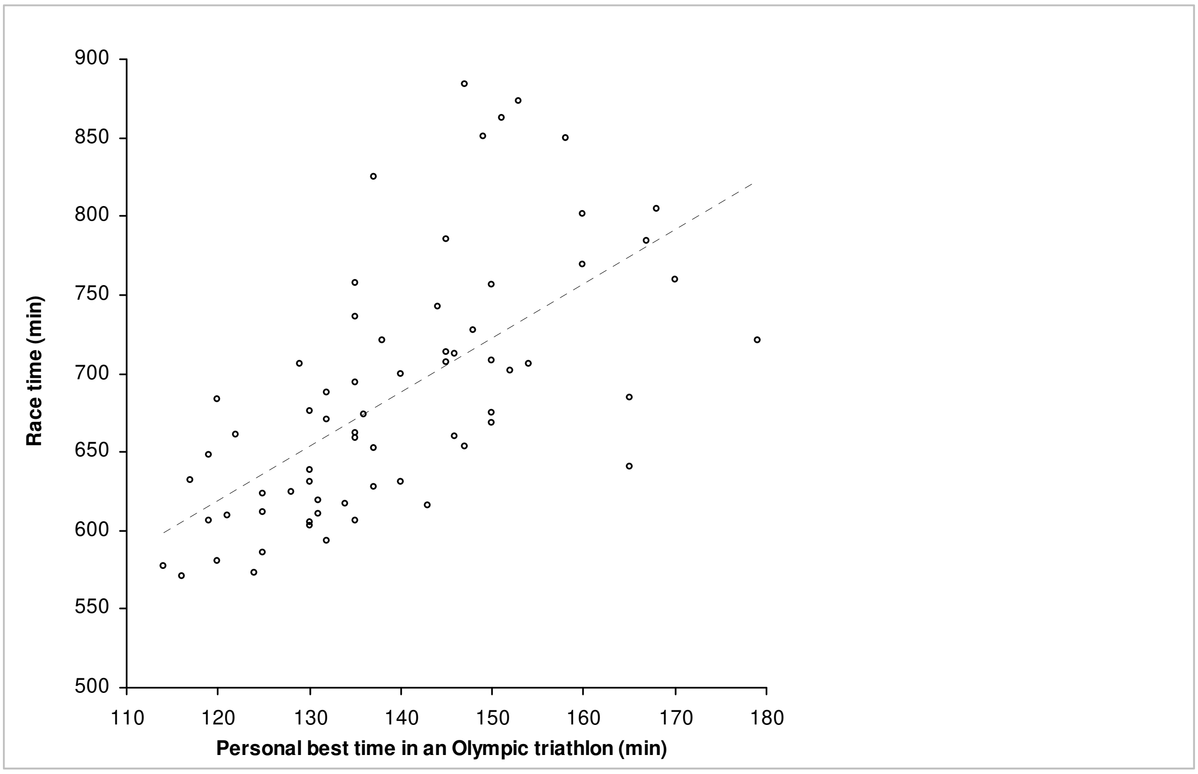

Fig. 3. Personal best time in an Olympic triathlon was related to the Ironman race time (n=67) with $r = .64$ (95% CI .47 to .76) ($p < .05$).

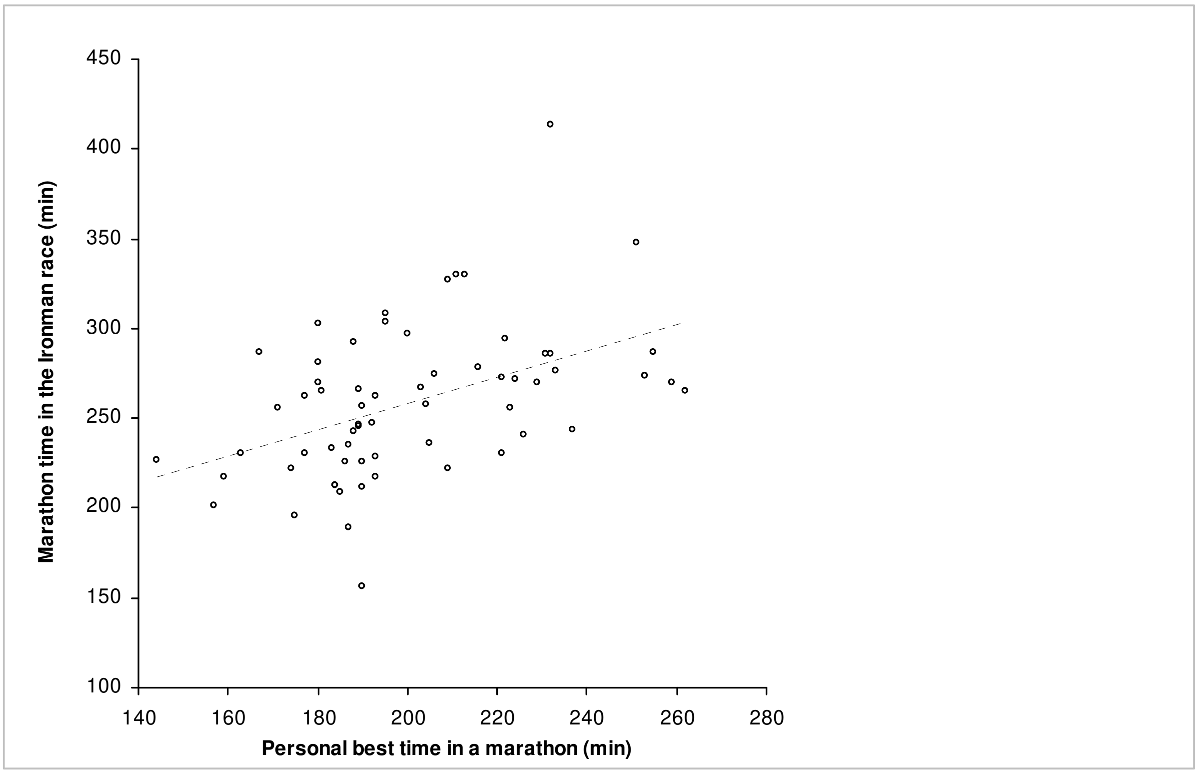

Fig. 4. Personal best marathon time was related to the split time for running in the Ironman (n=63) with $r = .46$ (95% CI .24 to .63) ($p < .05$).