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Effects of Body Composition on Race Time in Triathletes

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ABSTRACT The present paper aims to examine the effect of body composition of triathletes on race time. Forty-three athletes who took part in 9th World Inter-university Triathlon Championship participated voluntarily in measurements for the paper. The findings showed that Body Fat Percentage (BFP), Body Fat Mass (BFM), Fat Free Mass (FFM), Total Body Water (TBW) affected race time at $p<0.01$ level., While Body Mass Index (BMI) influenced the race time at $p<0.05$ level. Considering correlation results of the race time, positive moderately significant relation was found between race time and BFM and BFP, while negative moderately significant relation was observed between race time and FFM and TBW, and weak negative significant relation was seen between race time and BMI. Consequently, cycling time, rather than running time seems to be crucial in success in a University Olympic Triathlon. Swimming time seems to be of low importance.

INTRODUCTION

The notion of body composition is generally used to refer to Body Fat Percentage (BFP) a Body Fat Mass (BFM) and Fat Free Mass (FFM) (Martin and Ward 1996; Hills et al. 2001). Densities of fat and fat free tissue differs. Neurons, skeletal muscles, heart and veins and bones compose the fat free body mass. Regardless of the sport discipline, it is important that athletes have favorable anthropometric and physiological characteristics to improve performance. With respect to anthropometric characteristics, Knechtle et al. (2011) showed that low BFP and higher lean body mass are associated with higher performance in cycling and triathlon competitions. In one study Rüst et al. (2012) found that there were differences in muscle mass between cyclists and triathletes. In another study Moro et al. (2013) determined that the anthropometric characteristics of triathletes are more similar to those of cyclists.

Triathlon is closely related with somatotype, physiological capacity, technical proficiency and strategy (Ofoghi et al. 2016). Ideally, association of three triathlon disciplines is decisive in success (Millet and Vleck 2000). Various factors that affect performance in endurance sports have been studied in previous researches. "Apart from physiological parameters, a variety of anthropometric parameters like body mass, (Bale et al. 1986; Sharwood et al. 2002), BMI, (Hagan 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), thigh girth, (Tanaka and Matsuura 1982), total skinfolds (Bale et al. 1986) and skinfold thickness of the lower limb (Arrese and Ostariz 2006; Legaz and Eston 2005) show an influence on performance in endurance athletes". The triathlon in which such disciplines as swimming, cycling and running that require general endurance are performed successively, external and internal factors like climate and water temperature, use of tools for sports and, body composition also influence performance. Anthropometric attributes and "exercise performance during short and middle-distance running, marathon, and triathlon have been reported" (Arrese and Ostariz 2006; Legaz and Eston 2005; Sharwood et al. 2002). Baur et al. (2015) stated that triathlon results in dramatic alterations in body composition. They were determined that after triathlon race triathletes' fat mass and body fat percentage are reduced, TBW percentage is increased, and FFM and absolute TBW are remained same. These changes that occurred in the body composition of triathletes can affect their performance closely. For this reason the present paper aims to reveal the effect of body composition, on race time of university triathletes.

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Objectives

The objective of the present paper is to investigate the effect of body composition of triathletes, participating in 9th World Inter-University Triathlon Championship on race time, thereby on their performance.

METHODOLOGY

Subjects

The paper is composed of the data collected from 9th World Interuniversity Triathlon Championship held in the district of Erdek in Balikesir, Turkey in which 81 male and 59 female athletes from 25 countries raced. 66 voluntary athletes participated in this paper. Since only 43 athletes managed to complete the race, the paper was evaluated on these 43 athletes. Average ages of 17 female and 26 male athletes participating in the race were found 21.41±2.60 years and 22.88±2.14 years respectively. While their average heights were 168.88±6.59 cm and 175.31±19.73 cm respectively, and their average body masses were 56.85±6.44 kg, 69.97±8.27 kg respectively.

The temperature was about 40°C during the competition day. First females and then male athletes competed in the race. Race time of the athletes in each discipline were recorded and evaluated by the evaluation commission after the competitions. The athletes first swam for 1.5 km and then cycled on 40 km race track and finally ran about 10 km.

Height (cm), and Weight (kg) Measurements

"Height was measured to the nearest 0.1 cm by using a stadiometer. Weight was measured to the nearest 0.1 kg on an electronic scale" (Seca Corp, Birmingham, United Kingdom).

Body Composition Measurements

Their body composition was measured at fasting, and wearing shorts and t-shirt right before the competition by bio impedance analyzer (Tanita BC 418 Body Composition Analyzer). BFP (%), BFM (kg), FFM (kg), TBW (kg) and BMI parameters were considered for evaluation of body composition.

Statistical Analysis

The SPSS 16.0 statistical program was employed for assessment and analysis of the data. The researcher then summarized the data and calculated standard deviations and the means. To explain relationship between measurements, Pearson correlation analysis was used in accordance with the test of normality results, and linear regression analysis was used to predict power of explanation on BFP, fat mass, fat free mass, total body water on swimming, bicycle, running performance time and total race time. The significance level was accepted as 0.05 and 0.01.

RESULTS

The parameters are classified as directly measured properties, physical characteristics (age, height, weight), performance times (swimming, cycling, running and total race time) and calculated properties (BFP, BFM, FFM, TBW, BMI); used for multiple regression analysis. Total time of the race of male and female triathletes was 135.09±9.83 min (Swimming Time 20.87±1.26 min, Cycling Time 75.98±5.34 min, and Running Time 37.64±4.07 min) (Table 1).

Table 1: Physical and general characteristics of the subjects

Parameters	*Female (n=17)*	*Male (n=26)*	*Total (n=43)*
Age (year)	21.41± 2.60	22.88± 2.14	22.30± 2.42
Height (cm)	168.88± 6.59	175.31± 19.73	172.76± 16.08
Weight (kg)	56.85± 6.44	69.97± 8.27	64.79± 9.93
Swimming time (min.)	21.80± 1.09	20.26± 0.96	20.87± 1.26
Cycling time (min.)	81.57± 3.18	72.33± 2.50	75.98± 5.34
Running time (min.)	41.06± 2.92	35.42± 3.04	37.64± 4.07
Total time of the race (min.)	145.35± 4.60	128.39± 5.52	135.09± 9.83
Body fat percentage (%)	12.90± 2.25	8.32± 2.81	10.13± 3.43
Body fat mass (kg)	7.41± 1.91	5.71± 1.96	6.38± 2.09
Fat free mass (kg)	49.46± 5.06	63.11± 6.76	57.72± 9.09
Total body water (kg)	36.22± 3.70	46.20± 4.95	42.26± 6.65
BMI (kg/m^2)	19.88± 1.40	21.47± 1.30	20.85± 1.54

Source: U. Bilgin

The model is found to be meaningful in the regression analysis results of body fat mass, fat free mass, BFP, and total body water (p<0.01). A significant relationship existed between running time with body fat mass, fat free mass, BFP and total body water (p<0.01). On the other hand, the model is not found to be meaningful in the regression results of BMI (p>0.05). The relationship existed between running time, and BMI is not significant (p>0.05). A unit increase in body fat mass, fat free mass, BFP and total body water lead to changes in the rate of 79.2 percent, 19 percent, 64.1 percent, and 24.9 percent respectively in running time (Table 2).

The model is found to be meaningful in the regression analysis results of FFM and total body water (p<0.05). On the other hand, the model is not found to be meaningful in the regression results of body fat mass, BFP and BMI (p>0.05). A significant relationship existed between swimming time and FFM and total body water (p<0.05) whereas no significant relationship existed between swimming time and body fat mass, BFP and BMI (p>0.05). A unit increase in lean body mass and total body water, lead to a change in the rate of 5 percent, and 6.8 percent respectively in swimming time (Table 3).

The model is found to be meaningful in the regression results of body fat mass, fat free mass, BFP, total body water and BMI (p<0.01). A significant relationship existed between bicycle time with body fat mass, fat free mass, BFP, total body water and BMI (p<0.01). A unit increase in body fat mass, fat free mass, BFP, and total body water lead to changes in the rate of 128.1 percent, 44.6 percent, 113.8 percent, 61 percent and 151.3 percent respectively in bicycle time (Table 4).

The model is found to be meaningful in the regression results of body fat mass, fat free mass, BFP, total body water (p<0.01) and body mass index (p<0.05). A significant relationship existed between race time with body fat mass, fat free mass, BFP, total body water (p<0.01) and BMI (p<0.05). A unit increase in body fat mass, fat free mass, BFP, total body water and BMI lead to changes in the rate of 196.8 percent, 66.2 percent, 182.2 percent, 90.5 percent and 234.5 percent respectively in race time (Table 5).

Table 2.: Regression analysis between running race time and body composition

	Variables	*B*	*Standard error*	*Beta*	*t*	*p*
Dependent Variable =	Body fat mass	0.792	0.278	0.407	2.854	0.007**
Running Time	R = 0.407 R^2 = 0.166		F = 8.146	P = 0.007		
	Fat free mass		-0.190	0.063	-0.424	-2.996
0.005**						
	R = 0.424 R^2 = 0.180		F = 8.974	P = 0.005		
	Body fat percentage	0.641	0.156	0.540	4.109	0.000**
	R = 0.540 R^2 = 0.292		F=16.886	P = 0.000		
	Total body water	-0.259	0.087	-0.424	-2.996	0.005**
	R = 0.424 R^2 = 0.180		F = 8.974	P = 0.005		
	Body mass index	-0.661	0.400	-0.250	-1.652	0.106
	R = 0.250 R^2 = 0.062		F = 2.728		P = 0.106	

Source: U.Bilgin

Table 3.: Regression analysis between swimming race time and body composition

	Variables	*B*	*Standard error*	*Beta*	*t*	*p*
Dependent Variable =	Body fat mass	0.051	0.095	0.083	0.535	0.596
Running Time	R = 0.083	R^2 = 0.007		F = 0.286	P = 0.596	
	Fat free mass	-0.050	0.021	-0.353	-2.419	0.020*
	R = 0.353	R^2 = 0.125		F = 5.849	P = 0.020	
	Body fat percentage	0.091	0.056	0.245	1.618	0.113
	R = 0.245	R^2 = 0.060		F = 2.618	P = 0.113	
	Total body water	-0.068	0.028	-0.352	-2.408	0.021*
	R = 0.352	R^2 = 0.124		F = 5.800	P = 0.021	
	Body mass index	-0.186	0.125	-0.227	-1.494	0.143
	R = 0.227	R^2 = 0.052		F = 2.232	P = 0.143	

Source: U.Bilgin* $p<0.05$

Table 4.: Regression analysis between bicycle race time and body composition

	Variables	*B*	*Standard error*	*Beta*	*t*	*p*
Dependent Variable = Bicycle Time	Body fat mass	1.281	0.464	0.450	2.761	0.010**
	R = 0.450		R^2 = 0.203	F = 7.622	P = 0.010	
	Fat free mass	-0.446	0.079	-0.718	-5.643	0.000**
	R = 0.718		R^2 = 0.515	F = 31.846	P = 0.000	
	Body fat percentage	1.138	0.217	0.641	5.235	0.000**
	R = 0.691		R^2 = 0.477	F = 27.406	P = 0.000	
	Total body water	-0.610	0.108	-0.718	-5.650	0.000**
	R = 0.718		R^2 = 0.516	F = 31.926	P = 0.000	
	Body mass index	-1.513	0.487	-0.436	-3.104	0.003**
	R = 0.436		R^2 = 0.190	F = 9.634	P = 0.003	

Source: U.Bilgin** p<0.01

Table 5.: Regression analysis between race time and body composition

	Variables	*B*	*Standard error*	*Beta*	*t*	*p*
Dependent Variable = Race Time	Body fat mass	1.968	0.666	0.419	2.954	0.005**
	R = 0.419		R^2 = 0.175	F = 8.727	P = 0.005	
	Fat free mass	-0.662	0.133	-0.613	4.962	0.000**
	R = 0.613		R^2 = 0.375	F = 24.619	P = 0.000	
	Body fat percentage	1.822	0.345	0.636	5.276	0.000**
	R = 0.636		R^2 = 0.404	F = 27.837	P = 0.000	
	Total body water	-0.905	0.182	-0.612	-4.960	0.000**
	R = 0.612		R^2 = 0.375	F = 24.600	P = 0.000	
	Body mass index	-2.345	0.927	-0.367	-2.530	0.015*
	R= 0.367		R^2= 0.135	F = 6.399	P= 0.015	

Source: U. Bilgin
* p<0.05 ** p<0.01

DISCUSSION

In the present paper, in which the effect of body composition, on race time, in triathletes is studied, no statistically significant effect of BFM and BFP on swimming time was reported. BMI showed no statistically significant impact neither on running, nor swimming time (p>0.05). All other parameters except the above mentioned ones had significant effect on swimming, cycling and running time at p<0.05 and p<0.01 levels. In the evaluation of total race time, BFP, BFM, FFM, TBW had an effect on race time at p<0.01, while BMI showed an impact on race time at p<0.05.

Considering correlation analysis results between race time and parameters measured;

1) BFM $_{(R=0,419)}$ and BFP $_{(R=0,636)}$ were reported to have moderately positive significant relation with race time (p<0.01) (Table 5). It can be pointed out that just as BFM and BFP values increase, so do the race finishing time of triathletes. In other words, the lower the BFM and BFP values are, the lower the race finishing time is. Increasing race time may account for lower performance, which is to mean existence of negative relation between BFM and BFP and performance.

2) Moderately negative significant relation was found between FFM $_{(R=-0,613)}$ and TBW$_{(R=-0,612)}$ and RT (p<0.01), while negatively weak significant relation was observed between BMI (R=-0,367) and RT (Table 5). Taking into consideration the parameters searched, it can be suggested that the more the values increase, the lower the race finishing time is. In other words, the lower the values are, the higher the race finishing time is.

"Fat is the main energy-rich substrate for long-lasting endurance performance" (Frykman et al. 2003; Knechtle and Kohler 2007; Reynolds et al. 1999). "Endurance exercise leads to a reduction of adipose subcutaneous tissue, as reported in several field studies" (Höchli et al. 1995; Knechtle and Kohler 2007; Raschka et al. 1991; Raschka and Plath 1992). When the link of the attributes with race performance was analyzed in details, anthropometric characteristics such as body mass (Knechtle et al. 2009a), BMI (Hoffman 2010; Knechtle et al. 2010), BFP (Hoffman 2008; Knechtle et al. 2009c; Knechtle et al. 2010a; Knechtle et al. 2010b; Knechtle et al. 2011a), the sum of skin-folds (Knechtle et al. 2009b; Knechtle et al. 2011a), the circumferences of limbs (Knechtle et al. 2008a; Knechtle 2009a), and training variables such as volume (Knechtle et al. 2010d), intensity (Knechtle et al. 2010; Knechtle et al. 2010a; Knechtle et al. 2010e), age and gender (Lepers 2008; Lepers and Maffiuletti 2011; Knechtle et al. 2012) and previous experience (Knechtle et al 2010a; Knechtle et al. 2011b; Knechtle et al. 2010b; Knechtle et al. 2010d; Knechtle et al. 2010e; Ofoghi et al. 2016) were related to race performance. In most studies conducted, body composition and structure are reported to be associated with physical performance (Docherty and Gaul 1991; Khanna et al. 1998; Knechtle et al. 2008b; Ofoghi et al. 2016; Rowland 1991; Silva et al. 2012). In a study conducted by Knechle et al. (2015), athletes in Ironman and ultra-triathlon competition varied in terms of anthropometric and training attributes. In the race, not only Ironmen but also ultra-triathletes benefited from low body fat. However, ultra-triathletes were dependent more on training volume while speed in training was related to Ironman race time. Considering the results in the literature, increase or decrease in race time may positively or negatively influence performance. In parallel with the findings in this paper, it can be pointed out that body composition is effective on the race stages or total race time.

It was found "excessive body fat had negative effect on exercise performance and physical aptitude" (Docherty and Gaul 1991; Rowland 1991) and this negative effect was obvious in specifically physical activities where body mass was replaced both horizontally and vertically (Rowland 1991). It was also stated that BFP adversely effected performance in such disciplines as distance race, sprint and long-jump ignoring age and gender (Rowland 1991). "Another research has indicated that appropriate sport specific levels of relative fat and fat-free weight are beneficial to performance in most sports" (De Ridder et al. 1998). "In runners, an excess of adipose tissue usually requires a greater muscular effort to accelerate the legs, and, in theory, the energetic expenditure at the same velocity would be higher. Nevertheless, very few studies have reported the relation between body fat or sum of skin folds and running performance in homogeneous groups of elite athletes" (Conley and Krahenbuhl 1980; Legaz and Eston 2005).

The effects of BFM and BMI on performance have been investigated in several studies. (Herbst et al. 2011) "A positive effect of BMI on performance has been found in African endurance athletes in particular" (Knechle et al 2007). Knechle et al. (2007b) found that "BMI of ultra-triathletes is higher than that found for Kenyan runners: 24.7 kg/m^2 compared with 18.6 kg/m^2 for young Kenyan runners and 19.2 kg/m^2 for adult Kenyan runners. It is of interest that the BMI of the unsuccessful competitors in the race investigated here was 23.5 kg/m^2 and therefore lower than that of the finishers. A lower BMI was obviously not advantageous in this race". Knechle et al. (2007b) in their paper on World Championship Triple Iron Triathlon 2006 world-class ultra-triathletes stated no effect of such anthropometric properties as skeletal muscle mass, body mass index, body fat, skin fold thicknesses, circumference of extremities on race stages and total race time. While the literature includes studies on diverse results on the relation between BMI and running time, in the present paper no significant relation was observed between BMI and running time. Insufficient previous experiences in triathlon of university athletes participating in the race and their amateurish performance may account for the above mentioned relation (Knechtle et al. 2010b; Knechtle et al. 2010c; Knechtle et al. 2010d; Knechtle et al. 2010e; Knechtle et al. 2011).

In another paper conducted by Rüst et al. (2012) on 83 ironman triathletes with no different anthropometric properties and 84 ultra-cyclists, race time, expressed as a percentage of the course record was significantly less for the ultra-cyclists compared to the Ironman triathletes ($p<0.001$). They also found that BFM, BMI, FFM, BFP had close relation with race time. Therefore, the results in this paper show similarity with those in the relevant literature. BMI had no significant effect on swimming and running time though having significant impact on total race time, which may be caused by the fact that cycling time was longer than running and swimming time. Therefore, it can be argued that the longer the race time is, the more effective the BMI is on race time. Besides, while the athletes need greater muscular efforts in swimming and running stages to gain velocity for their extremities, the cyclists need lesser muscular efforts in activities where such a sports tool as bicycle is used to gain velocity. In most studies conducted, "An excess of subcutaneous adipose tissue means that greater muscular effort and therefore increased energy expenditure is required. It has been shown that physical performance is negatively related to body fat and positively related to skeletal muscle mass" (Christensen and Ruhling 1983).

In the papers conducted by Knechtle and Kohler (2009), they suggested that Triple Iron triathletes' running performance showed significant relation with race success, while no significant relation was seen between anthropometric properties (BMI, BFP and FFM) and success in race. In another paper conducted by Moro et al. (2013) on cyclists and triathletes, they stated that body composition and anthropometric characteristics were similar.

"In endurance athletes, the association between anthropometric characteristics such as body mass, body height, BMI, BFP has been investigated mainly in disciplines like swimming, cycling and running. Body mass was related to performance in runners" (Knechtle et al. 2009a) and both road (Swain 1994) and off-road cyclists (Gregory et al. 2007; Impellizzeri et al. 2005). BMI (Hoffman 2008) was also shown to be associated with performance in ultra-endurance runners. Besides, "Body fat showed an association with performance in female marathon runners" (Hagan et al. 1987) "in male ultra-marathoners" (Hoffman et al. 2010) and in female swimmers (Siders et al 1993; Tuuri et al. 2002).

Knechtle et al. (2010a) suggested that the anthropometry of triathletes is associated with total race time, rather than training volume (hours per week). It is therefore believed that training volume does not cause changes in the body composition of cyclists or triathletes with low levels of body fat. However, Knechtle et al. (2007b) in one of their studies found, "Race time was not significantly influenced by the anthropometric properties ($p>0.05$). No significant effect was observed between race time and the calculated parameters of BMI, body fat, and skeletal muscle mass ($p>0.05$). It is concluded that in an ultra-triathlon, BMI, body height, skin fold thicknesses, circumference of extremities, skeletal muscle mass, and body fat have no influence on race performance in world-class ultra-triathletes. Total race performance is associated with performance in cycling and running but not in swimming".

"In other studies, the effect of body fat on race performance is controversial. Whereas Hagan et al. (1987) found a positive correlation between marathon performance time and body fat in female runners, Christensen and Ruhling (1983) found that BFP did not correlate with finish times". In another paper Knechtle et al. (2010a) concluded that BFP showed a "relationship to total race time in male triathletes, and training volume showed an association with total race time in female triathletes. Presumably, the relationship between BFP, training volume, and race performance is genetically determined". In this paper, BFP and BFM suggested a positively significant relation with race time (Table 5). The results obtained concerning body composition values related to fat showed similarity with the studies conducted by Hagan et al. (1987) and Knechtle et al. (2010). In the literature, it was found that the results obtained in the papers on the effect of world-class triathletes' body composition on race time, were conflicting.

CONCLUSION

To conclude, there is significant association between body composition parameters and total race time in university Olympic triathletes. Cycling time rather than running time is a crucial element for success in a University Olympic Triathlon, while swimming time has rather low importance.

RECOMMENDATIONS

The results obtained in the present paper suggest that for triathletes to complete races at more appropriate time, become successful in swimming, cycling and running stages of the race and succeed in total race time, they should bear in mind that their lower body fat and higher muscle and water values, will influence their performance positively. In addition, studies on amateurish athletes should be taken into consideration more since fewer studies on university triathletes have been reported.

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