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Original Article

Comparison of body composition, heart rate variability, aerobic and anaerobic performance between competitive cyclists and triathletes

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Abstract. [Purpose] The aim of this study was to compare the body composition, heart rate variability, and aerobic and anaerobic performance between competitive cyclists and triathletes. [Subjects] Six cyclists and eight triathletes with experience in competitions voluntarily participated in this study. [Methods] The subjects' body composition was measured with an anthropometric tape and skinfold caliper. Maximal oxygen consumption and maximum heart rate were determined using the incremental treadmill test. Heart rate variability was measured by 7 min electrocardiographic recording. The Wingate test was conducted to determine anaerobic physical performance. [Results] There were significant differences in minimum power and relative minimum power between the triathletes and cyclists. Anthropometric characteristics and heart rate variability responses were similar among the triathletes and cyclists. However, triathletes had higher maximal oxygen consumption and lower resting heart rates. This study demonstrated that athletes in both sports have similar body composition and aerobic performance characteristics.

Key words: Triathletes, Cyclists, Anaerobic power

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INTRODUCTION

Triathlon is a challenging individual sport that involves the disciplines of cycling, swimming, and running; these disciplines are combined in a continuous manner through two transitions[1)]. The ability to sustain high metabolic power for long periods is very important for athletes competing in triathlons. Several field-based studies have shown that physiological and morphological functional characteristics change negatively with age[2, 3)]. It is very important that triathletes have suitable anthropometric and physiological characteristics to advance performance in the three disciplines involved. Some studies have found that anthropometric characteristics are associated with better performance, especially during the swimming and running components of triathlon competitions[4)]. The triathletes' anthropometry was found to account for 47% of the variance in triathlon performance Landers[5)]. It is also well known that endurance runners have low levels of body mass and that it is related to improved running performance[6, 7)]. Thus, success in a competitive sport is determined not by anthropometric characteristics alone, but by a combination of other characteristics such as physiological variables.

A high maximal oxygen uptake (VO_{2max}) is a physiological characteristic that plays an important role in the performance of triathletes in competitions. Measuring VO_{2max} is important to success in triathlon performance. However, VO_{2max} has not been shown to be a good predictor of triathlon performance in elite triathletes[8)]. In fact, the VO_{2max} plateau duration has more correlation to triathlon performance than the VO_{2max} value[9)]. Other important physiological characteristics, such as anaerobic power and capacity, which are required during to perform sprints, overtake, break away, or follow with the group, are very

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important for the performance of triathletes, particularly at the end of the triathlon competitions[10]. Heart rate recordings have been used to assess maximal heart rate, minimum heart rate, and training intensity among sportsmen, particularly in endurance sports[11]. Heart rate variability (HRV), which is analyzed from the heart rate recordings, provides information about the training load and psychophysiological status in endurance sports such as triathlons and cycling. A reduction in the high frequency component and an increase in the low frequency component of the power spectrum of HRV have been shown to relate with fatigue and training load[12], and it has been demonstrated that continued exposure to prolonged periods of intense cycling exercise (about 3-week) can cause a marked reduction in HRV indices in cyclists.

Thus, anthropometric characteristics may not be the only determinants of competitive athletic performance; a combination of other physiological characteristics such as maximal oxygen uptake and anaerobic power and capacity may also play significant roles. The objective of the study was to compare of body composition, heart rate variability, aerobic and anaerobic performance between competitive cyclists and triathletes.

SUBJECTS AND METHODS

After a 2-weeks pre-season training period for the participants in the aerobic and anaerobic performance tests, the anthropometric, body composition, and heart rate variability measurements were performed at a temperature-controlled performance laboratory in a public university. Six cyclists (age 32.3±3.0 yrs; height 175.5±5.5 cm; body mass 75.4±7.4 kg; training experience 9.7±4.8 yrs) and eight triathletes (age 36.2±5.6 yrs; height 181.6±4.1 cm; body mass 74.3±3.8 kg; training experience 10.6±2.9 yrs) (14 males athletes in total) who had participated for more than three years in regional and national competitions were recruited for the study. All the athletes were notified of the research procedures, requirements, benefits, and risks before obtaining informed consent. Written informed consent was obtained from all of the subjects. The study was approved by the research ethics committee of the local university and was conducted in a manner consistent with the institutional ethical requirements for human experimentation in accordance with the Declaration of Helsinki. Standardized testing procedures were followed as defined in the American College of Sports Medicine Guidelines (ACSM)[13]. All measurements were performed by the same researchers after overnight fasting, at a similar time of the day-in order to have similar chronobiological characteristics[14]. The temperature (20–22 °C) and relative air humidity (<60%) of the room were consistent throughout all the steps of the study. The subjects were asked not to exercise exhaustively on the day prior to assessment.

The height and weight were measured for each volunteer while they were wearing light clothing and no shoes and socks. Weight was measured to the nearest 0.1 kg using calibrated scales (Seca, Germany), while the height was measured to the nearest 0.1 cm using a calibrated stadiometer (Holtain Ltd, England). A Gulick anthropometric tape (Holtain) with an accuracy of ±1 mm was used to measure the circumferences of the waist, hip, abdominal, thighs, and calves. To estimate the body fat percentage, a seven site skinfold thickness technique was used with a scientific skinfold caliper (Holtain, UK) to the nearest 0.1 mm. The anatomical sites used were: the chest, abdominal, thigh, triceps, suprailium, subscapular, and iliac crest. Body density was estimated using the equation that has been validated for males aged 18 to 61 years[15]. The body density estimate was in turn used to estimate the body fat percentage using the Siri equation: [%Body fat = (495 / body density) − 450]. Fat mass was calculated by the transformation of the percent body fat values [fat mass = (body mass × %body fat)/100]. Lean body mass was determined by the fractionation of body mass into two components: lean body mass = body mass − fat mass). Body mass and body fat percentage were measured using Bioelectrical impedance analysis (TBF 401 A, Tanita, Tokyo, Japan). Two measurements were taken for each of these variables, and then the average values were used to perform the statistical analysis. All of the athletes completed an incremental treadmill test on a motorized treadmill (Cosmed, Italy) according to the procedures suggested by Rossato et al.[11]. During the test, the expired gases were analyzed using a breath-by-breath automated gas-analysis system (Oxycon Mobile; Viasys Healthcare, Hoechberg, Germany) and heart rate was monitored continuously throughout the test with a Polar S610 heart rate monitor (Polar, Finland). The highest 30-s. mean HR and VO_2 values measured during the test were used as maximum values (HR_{max} and VO_{2max}). Heart rate variability (HRV) was measured using the OmegaWave sport technology system (OmegaWave Technologies,LLC, Portland, OR, USA) as described in the manufacturer's reference manual and standardized guidelines for the measurement of HRV. HRV was tested, the athletes voided their bladders and lay in a supine position for 15 minutes in silence with the lights dimmed; the actual HRV recording took 6–7 min. before any strenuous activity[16].

After HRV test, the Wingate Anaerobic Test (WAnT) was conducted using a mechanically braked cycle ergometer (834 E, Monark, Vansbro, Sweden) according to the procedures suggested by Inbar et al.[17]. During the test, the athletes were verbally encouraged to give the maximum effort possible. At the end of the test, the peak power and mean power were calculated automatically by the WAnT test computer program. A fatigue index (FI) was calculated using the following equation[17]: FI = [(Peak Power Output-Minimum Power Output) / Peak Power Output] × 100. The data are reported as means and standard deviations. Before using the parametric tests, the assumption of normality was verified using the Shapiro-Wilk test. Differences in the all tests performance variables between the cyclists and the triathletes were tested by the nonparametric Wilcoxon signed rank tests for independent samples. Effect sizes (η^2) values of <0.20, 0.20–0.60, 0.60–1.2, 1.2–2.0, 2.0–4.0 were considered to represent small, moderate, large, very large and extremely large differences, respectively[18]. All statistical analyses were performed with the SPSS version 16.0, and the level of statistical significance was set at $p<0.05$.

RESULTS

Table 1 shows the anthropometric characteristics and body composition of the cyclists and triathletes. There were no significant differences between the anthropometric characteristics and body composition of the cyclists and triathletes. However, cyclists had a higher body fat percentage (17.7–19.3%, p=0.44, η^2=0.23 moderate effect) and fat mass (13.2–14.6 kg, p=0.44, η^2=0.22 moderate effect) compared to the triathletes. In addition, lean body mass was higher in the triathletes; however, no significant difference was found (61.1–60.8 kg, p=0.89, η^2 = 0.03 small effect).

Table 2 shows the aerobic performance of the cyclists and triathletes studied. There were no significant differences in the aerobic performances responses of the cyclists and triathletes. However, triathletes demonstrated higher VO_{2max} (58.5–57.7 mL.kg^{-1}.min^{-1}, p=0.85, η^2=0.07 small effect) and maximum power (7.1–6.8 W.kg^{-1}, p=0.21, η^2=0.14 small effect) compared to the cyclists. In addition, HR_{max} was higher in the cyclists, but no significant difference was found (187.1–193.5 b.min^{-1}, p=0.09, η^2=0.39 moderate effect).

Table 3 shows the anaerobic performance of the cyclists and triathletes. The cyclists group showed statistically significant differences in minimum power (377.5–471.7 W, p=0.02, η^2=0.57 moderate effect) and relative minimum power (5.1–6.3 W.kg^{-1}, p=0.02, η^2=0.55 moderate effect) compared to the triathletes.

Table 4 shows the heart rate variability responses of the cyclists and triathletes studied. There were no significant differences in any heart rate variability responses between cyclists and triathletes.

DISCUSSION

The aim of this study was to compare the body composition, heart rate variability, aerobic and anaerobic performances between competitive cyclists and triathletes. The study revealed no significant differences in the seven sites skinfold thicknesses, body fat percentage, fat mass, and lean body mass between cyclists and triathletes. Moro et al.[19] also found no differences in seven sites skinfold thicknesses in cyclists and triathletes, except for medial calf skinfold thickness. In addition, Laursen et al.[20] observed no significant differences in body mass or the sum of five skinfolds between cyclists and triathletes. Furthermore, Rüst et al.[4] found no differences in anthropometric characteristics and body composition between triathletes

Table 1. Anthropometric characteristics and body composition of the cyclists and triathletes

Skinfold thickness	Triathletes (n=8)	Cyclists (n=6)
Chest (mm)	10.1±4.3	10.3±3.6
Abdominal (mm)	17.9±2.7	19.2±3.2
Thigh (mm)	12.7±3.6	14.9±2.3
Triceps (mm)	9.9±1.9	12.6±3.7
Supraspinal (mm)	11.8±3.9	12. 8±4.4
Subscapular (mm)	12.8±4.8	12.9±4.3
Iliac crest (mm)	7.9±1.9	9.7±2.6
Sum 7SF (mm)	83.2±23.2	92.5±24.1
Body fat (%)	17.7±3.2	19.3±3.2
Fat mass (kg)	13.2±2.8	14.6±3.2
Lean body mass (kg)	61.1±2.7	60.8±3.7

Table 2. Aerobic performance of cyclists and triathletes

Incremental Treadmill Test	Triathletes (n=8)	Cyclists (n=6)
VO_{2max} (ml.kg^{-1}.min^{-1})	58.5±5.7	57.7±5.8
HR_{max} (b.min^{-1})	187.1±8.1	193.5±6.7
$HR_{resting}$ (b.min^{-1})	59.6±7.3	60.7±9.5
Maximum power (W)	527.5±64.8	516.6±62.1
Maximum power (W.kg^{-1})	7.1±0.9	6.8±0.8

Table 3. Anaerobic performance of cyclists and triathletes

WaNT	Triathletes (n=8)	Cyclists (n=6)
Peak power (W)	796.4±74.6	933.3±189.5
Peak power (W.kg^{-1})	10.7±1.3	12.4±2.3
Average power (W)	586.9±45.8	702.5±139.3
Average power (W.kg^{-1})	7.9±0.8	9.3±1.7
Minimum power (W)	377.5±29.0	471.7±90.9*
Minimum power (W.kg^{-1})	5.1±0.4	6.3±1.2*
Fatigue index (%)	52.4±4.1	49.3±2.2

* p< 0.05

Table 4. Heart rate variability responses of cyclists and triathletes

HRV	Triathletes (n=8)	Cyclists (n=6)
SDNN (ms)	50.2±16.8	57.2±20.9
RMSSD (ms)	35.7±18.8	42.2±24.2
TP (ms^2)	1066.0±860.7	804.7±756.4
LF (ms^2)	643.4±545.5	537.0±411.1
HF (ms^2)	279.1±314.8	456.2±420.6
LF/HF	4.3±3.7	2.4±3.0
LFnu	72.1±15.1	58.7±19.1
HFnu	27.9±15.1	41.2±19.1
VLF (ms^2)	161.9±202.2	131.5±70.1

SDNN: standard deviation of RR interval; RMSSD: root mean square of successive differences in RR intervals; TP: total power; LF: low frequency; HF: high frequency components; nu: normalized units; VLF: very low frequency components and cyclists. In contrast, Millet et al.[21], found significant differences in height and body mass between competitive cyclists and triathletes. Brunkhorst and Kielstein[7], found that cyclists who were males had a higher BMI and larger thighs and were taller when compared to the male triathletes. In addition, Landers et al.[5] reported a strong and positive correlation between height and mass in elite triathletes who were males. These reported findings are similar to the results of the present study and indicate that anthropometric characteristics are similar in competitive cyclists and triathletes. Previous researches have shown that the physical characteristics of athletes may play a role in determining performance. The participant's anthropometry was found to account for 47% of the variance in triathlon performances[5], and low levels of adiposity positively influenced swimming and running performance during triathlons[4, 22]. Other performance and anthropometric characteristics studies have revealed that endurance runners have low levels of body mass and reduced skinfold thickness, which are related to improved running performance[6]. Given these findings, successful performance may not be determined only by physiological characteristics, but it may also be affected by a combination of anthropometric and physiological characteristics. Knechtle et al.[22] suggested that the anthropometry of triathletes is associated with training volume. The seven sites skinfold thickness, body fat percentage, and fat mass were lower in triathletes than in cyclists (Table 1). These finding can be explained by the nature of triathlon training, because running training and overall training volume cause a reduction in the skinfold thickness of the lower limbs.

The present study also showed that triathletes had higher relative VO_{2max} values compared to cyclists. Similarly, triathletes generally possess high VO_{2max} values in studies, compared with cyclists in studies[19]. We believe this might be because triathletes divide their training time into three disciplines (swimming, cycling, and running) and their training volume and overall training time are higher than that of cyclists. Generally, VO_{2max} values are reported as relative because of extra body mass affects running performance negatively. For example, Costill et al.[23] reported a relationship between both absolute and relative VO_{2max} and running performance, and a stronger relationship was found for relative compared to absolute VO_{2max} (r=0.83 and 0.59 respectively). The specificity of each discipline can influence the aerobic performance; cyclists achieve a higher performance than triathletes in cycling tests, whereas the opposite is observed in running tests[24]. Numerous studies have demonstrated that VO_{2max} and Wpeak value measured by treadmill are higher for triathletes compared to cycle ergometer[25]. The present study also showed that triathletes had higher maximum power measured with treadmill compared to the cyclists' maximum power measured by cycle ergometer. In similar with our result, Mujika and Padilla[26] showed that Wpeak value of 440±3.3 W was reported for 14 elite cyclists, compared to a Wpeak of 439 W for 24 professional cyclists. We believe that this difference might be because of the specific features of the individual sports, their requirements, and the different measurement tools.

The Wingate anaerobic test (WaNT) is the gold standard for evaluating anaerobic capacity[17]. There were no significant differences in absolute and relative peak and average power and fatigue index obtained on the WaNT between the cyclists and triathletes, except for minimum power. In a similar study showed that triathletes and cyclists had lower peak power and mean power than we found in our results. Furthermore, higher values of peak power and average power have been reported for cyclists, although similar statistical results to the present study have been obtained in the literature[19]. According to the sport-specific requirements, anaerobic power and capacity are more important for cyclists than triathletes. A cycling race is characterized by power maintained for prolonged periods of time and high peak power for short periods of time for sprints[8]. In contrast, triathletes perform fewer sprints during the cycling race than cyclists, since a higher demand on the anaerobic energy system during cycling may accelerate the process of muscle fatigue, and reduce the performance of the triathletes during running. However, it is believed that anaerobic fitness is important for the performance of triathletes, since the intervals in short-distance triathlon races permit the athletes to perform sprints when they overtake, break away, or follow with the group and when they pick up speed again[1]. In addition, a previous study demonstrated a relationship between running speed and heart rate from low to submaximal speeds[27].

One limitation of the present study is the fact that we monitored HRV for 7 min. Prolonged recordings (24-hour) for HRV is a better assessment to reflect training load and to collect psychophysiological information for this study. In conclusion, the anthropometric characteristics, aerobic and anaerobic profile, and heart rate variability were similar in triathletes and cyclists. Triathletes demonstrated higher VO_{2max}, power outputs and fatigue indexes, suggesting that the specificity of their training caused different anthropometric, psychophysiological, and physiological adaptations in triathlon and cycling. These parameters could provide further information about the anthropometric and psychophysiological profile of cyclists and triathletes.

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