Original Article

Pulmonary function and anthropometric characteristics in elite triathletes.

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Abstract

Problem statement: Pulmonary function and anthropometric characteristics influence athletes' performance and development during their trainings and also during their competitions. **Approach:** Duathlon and long-distance triathlon are endurance sports where athletes must perform disciplines like swimming, cycling and running over various distances. The relationship between pulmonary function and anthropometric characteristics is remarkable in triathlon, and gender seems to play an important role in this relationship as it has been demonstrated by many authors. **Purpose:** The purpose of this study was to analyse the differences in pulmonary function among athletes from duathlon and long-distance triathlon, taking gender into consideration, and to determine the relationship between pulmonary function and anthropometric characteristics in this sport. **Results:** 33 athletes (11 subjects from long-distance triathlon and 22 subjects from duathlon) were recruited for this study. Height and weight were measured, and spirometry was performed 3 times in order to test pulmonary function parameters. The pulmonary function data analysed were forced vital capacity, forced expiratory volume during the first second and peak of expiratory flow. The only statistically significant difference between duathletes and long-distance triathletes was observed in the peak of expiratory flow, and there were no differences between genders. Body mass index is only correlated with forced vital capacity in subjects who performed long-distance triathlon, and height is correlated with all the pulmonary function data in duathlon. **Conclusion:** Long-distance triathlon athletes have significant higher levels of the peak of expiratory flow than duathletes in this sample. Gender does not play an important role in pulmonary function parameters, but it does in anthropometric characteristics for both sports.

Key words: lung function; anthropometrics; endurance sports; physiotherapy..

Introduction

Performance of an athlete during a competition depends on multiple factors, but, as it is shown in scientific literature, pulmonary function and anthropometric characteristics play an important role. These measurements can define the physical condition of athletes and also help them to implement individual or specific training in order to improve their conditions (Bilgin et al., 2010; Knechtle et al., 2010; Millet et al., 2003).

There is a close relationship between lung function and anthropometric measurements, as both are indicators of the level of training and performance, but also, good measurements of anthropometrics are associated with better parameters in a pulmonary function test (Bilgin et al., 2010; Johari et al., 2017; Millet et al., 2003; Stocker et al., 2019).

Previous studies have checked pulmonary function parameters in different sports, such as running or swimming, finding very useful results in order to plan trainings and to know the performance of athletes both during trainings and competitions (Akhade&Muniyappanavar, 2014; Ondolo et al., 2009).

As pulmonary function parameters seem to have a close relationship with performance and the recognition of future talent, studies in young athletes have been performed in order to confirm this possible correlation (Díaz Molina et al., 2009).

Both pulmonary function and anthropometric characteristics have been compared between athletes and sedentary people, always finding better results in both items for athletes, who always had higher pulmonary function parameters (Henrique G. et al., 2019; Vedala et al., 2013).

Determination of anthropometric and pulmonary measurements in sports like duathlon or long-distance triathlon is important for many reasons, as these characteristics are demonstrated to influence performance during competition in these sports (Johari et al., 2017) and can also provide very interesting data in order to improve training's quality (Johari et al., 2017; Knechtle et al., 2010). Triathlon is a multisport race consisting of different modalities and distances of swimming, cycling and running (Millet et al., 2003). Standard distances in triathlon are more common than the Olympic distance or Ironman, but in this championship, athletes performed

different distances (Millet et al., 2003; Seedhouse et al., 2006). Studies on pulmonary function and anthropometric characteristics have never been reported for these distances.

Long-distance triathlon is an endurance sport involving 3 disciplines: swimming, cycling and running. In this case, during long-distance triathlon, athletes perform 3 kilometres swimming, 113 kilometres cycling and 30 kilometres running.

Duathlon is also an endurance sport but consisting only of two sports: cycling and running, and in this case, performing a shorter distance than in long-distance triathlon (10 kilometres running, 40 kilometres cycling and 5 kilometres running again).

Gender seems to play an important role in both long-distance triathlon and duathlon. Some studies showed differences between genders in parameters like lung function (Johari et al., 2017) and body mass index or body fat percent (Bilgin et al., 2010). These differences can be advantageous in many ways, such as performing better race times, but also disadvantageous in other aspects, such as more weight during swimming, so its importance in competition is remarkable (Bilgin et al., 2010; Jhonny K. F. Da Silva, Alysson A. N. Enes, Bruna B. Sotomaior, Maria A. Ruy Barbosa, Rafael O. De Souza, Raul Osiecki., 2020; Johari et al., 2017).

Moreover, previous studies about pulmonary function or anthropometric characteristics in triathlon were developed with samples conformed only by males (Bilgin et al., 2010; Knechtle et al., 2010; Millet et al., 2003). This fact does not allow to compare findings between genders and does not take physiological and physical differences between males and females into consideration, so results are incomplete on many occasions. In order to check the pulmonary function in duathletes and long-distance triathletes, spirometry is shown as the main technique to examine it. It is an easy and costless method which provides quick results about all the pulmonary function parameters. Forced spirometry was chosen, since it is the appropriate modality for athletes, not only because it provides data from maximal volumes, but also because it provides data from the strength of respiratory muscles (Miller et al., 2005).

The purpose of this study was to analyse the differences in pulmonary function among athletes from duathlon and long-distance triathlon, measured by spirometry, and to determine the relationship between the pulmonary function parameters obtained and anthropometric characteristics, taking gender into consideration.

Materials and Methods

Participants

33 subjects, 11 from long-distance triathlon (10 males and 1 female) and 22 from duathlon (11 males and 11 females) with an average age of 37.2 ± 7.03 years in duathlon and 34.3 ± 6.3 years in long-distance triathlon were recruited for this study. They were all elite athletes participating in the ITU World Triathlon Multisport Championship, developed in Pontevedra (Spain) during April and May, 2019.

All subjects were informed about the procedures before doing the measurements, and The Declaration of Helsinki (2013) was followed. An informed consent was signed by all the recruited participants.

Measurements

The measurements obtained were height and weight in order to calculate body mass index, and pulmonary function parameters like forced vital capacity (FVC), forced expiratory volume during the first second (FEV1) and peak of expiratory flow (PEF). FVC is defined as the amount of air exhaled forcibly after taking a deep breath, FEV1 is the maximal amount of air exhaled forcibly in the first second of expiration, and PEF is the maximum speed of expiration (Johari et al., 2017; Knechtle et al., 2010).

Design and procedures

The intervention consisted of, firstly, measuring height and weight, so that body mass index could be calculated later. Height was obtained with a measuring tape and weight was obtained with a weighbridge. After obtaining these data and informing all subjects about the intervention, spirometry was performed.

The spirometer used was Datospir 120C (Sibelmed), and the test chosen was forced spirometry, which is the most appropriate for elite athletes, which also provides data as FVC, FEV1 and PEF.

All the parameters obtained by forced spirometry are essential for athletes, since knowing its values could provide improvements in trainings and help to predict performance during competitions too (Johari et al., 2017; Knechtle et al., 2010).

Participants were asked to come to the test 30 minutes after finishing the competition, and information about how to perform the spirometry and about results was given during and after the intervention. Before doing the test, data about age, height, weight and gender was introduced in the spirometer just to calculate the reference values of pulmonary function. The spirometer calculates these reference values and provides information about pulmonary function of healthy but non-professional athletes-subjects with the same characteristics.

Forced spirometry consisted in doing a maximal mouth inspiration followed by a maximal mouth expiration by means of a nose clip. The spirometer registered the entire expiration and obtained data about the amount of air exhaled, the speed of the exhalation and the strength of the expiration. Subjects were sat with the neck in neutral position, not flexed or extended, and they could not cough during the procedure. They were asked

to perform the test 3 times, and the spirometer chose the best attempt with the highest values of all variables, which were used for the study (Miller et al., 2005),

Statistical analysis

Statistical analysis was carried out with the software SPSS (version 25.0, Chicago, IL, USA). T-test was used to compare pulmonary function parameters (FVC, FEV1 and PEF) among subjects from long-distance triathlon and duathlon, and ANOVA test was used to show the differences between males and females in duathlon and with regard to their anthropometric characteristics. The differences between males and females in long-distance triathlon were not analysed, since there was only one female in the sample. Correlation between anthropometric characteristics (body mass index and height) and pulmonary function parameters was analysed by the Pearson correlation coefficient. All tests had a significance level of 0.05. Effect size for T-test and ANOVA test was studied by Cohen's D.

Results

22 subjects from duathlon and 11 subjects from long-distance triathlon were analysed. Age, height, weight and body mass index are shown in Table 1, by using mean and standard deviation.

Table 1. Anthropometric characteristics

	Duathlon	Long-distance triathlon
Age	37.2 ± 7.03	34.3 ± 6.3
Gender	11 male 11 female	10 male 1 female
Height	168.9 ± 8.44	182.9 ± 4.34
Weight	61.18 ± 8.68	72.1 ± 7.65
Body mass index	21.35 ± 1.75	21.5 ± 1.73

Pulmonary function parameters, FVC, FEV1 and PEF, were compared among subjects from long-distance triathlon and duathlon. Results from this comparison are shown in Table 2 by the use of mean and standard deviation.

Table 2. T-test for the pulmonary function between sports

	DUATHLON	LDT	p-value	Effect size (CI 95%)
	Mean (SD)	Mean (SD)		
PEF	8.73 (2.6)	9.56 (1.4)	0.039*	0.36 (-1.09-0.35)
FVC	4.16 (0.96)	5.8 (0.8)	0.454	1.78 (-2.64-0.95)
FEV1	3.66 (0.96)	4.63 (0.72)	0.211	1.09 (-1.86-0.32)

LDT: long-distance triathlon; SD: standard deviation; CI: confidence interval.

*Significance level of 0.05

As table 2 shows, only PEF had significant differences between long-distance triathlon and duathlon ($p < 0.05$). Athletes who performed long-distance triathlon had significantly higher values of PEF than duathletes. As for gender, there were no significant differences between males and females in duathletes' pulmonary function. These findings are shown in table 3.

This analysis was not performed in long-distance triathlon athletes, since this sample only had one female.

Table 3. Differences between male and female in pulmonary function of duathletes

	DUATHLON		P value	Effect size (CI 95%)
	Male Mean (SD)	Female Mean (SD)		
PEF	10.64 (9.22)	6.82 (6.12)	0.001	0.49 (0.36-1.34)
FVC	4.78 (4.19)	3.56 (0.16)	0.001	0.41 (0.43-1.26)
FEV1	4.25 (3.65)	3.09 (2.72)	<0.0001	0.36 (0.48-1.2)

SD: standard deviation; CI: confidence interval.

The anthropometric characteristics studied were body mass index and height for both sports (long-distance triathlon and duathlon). Table 4 and 5 show the correlations between these anthropometric variables and data from pulmonary function test parameters.

Table 4. Pearson correlation coefficient between pulmonary function and body mass index.

	DUATHLON	LONG-DISTANCE TRIATHLON
	r (p-value)	r (p-value)
PEF	0.207 (0.355)	0.011 (0.984)
FVC	0.238 (0.287)	0.847 (0.033)*
FEV1	0.187 (0.406)	0.418 (0.410)

r: Pearson correlation coefficient

*Significance level of 0.05

Table 5. Pearson correlation coefficient between pulmonary function and height.

	DUATHLON	LONG-DISTANCE TRIATHLON
	r (p-value)	r (p-value)
PEF	0.761 (<0.001)**	0.227 (0.665)
FVC	0.731 (<0.001)**	0.510 (0.302)
FEV1	0.747 (<0.001)**	0.378 (0.460)

r: Pearson correlation coefficient

***Significance level < 0.001

Body mass index only shows a significant and positive correlation with FVC in athletes from long-distance triathlon, and height is correlated with all the pulmonary function parameters in duathlon, but with none of them in long-distance triathlon.

Male duathletes had no significant differences in height compared with females, but they did in body mass index, where males had higher values than females.

Discussion

The purpose of this study was to compare pulmonary function in two different modalities (duathlon and long-distance triathlon), taking gender into consideration and analysing the correlation between these lung parameters and anthropometric characteristics, such as body mass index and height.

The main result obtained was that only PEF revealed significant differences among athletes performing long-distance triathlon and duathlon. There were also no significant differences between males and females in duathletes' pulmonary function, neither in PEF, nor in FVC and FEV1. About the anthropometric characteristics, body mass index was only correlated with FVC in long-distance triathlon, and height had a significant correlation in all the pulmonary function parameters in duathletes. Male duathletes had significant differences in body mass index compared with female duathletes, but not in height.

Studies performed in other populations show similar findings. The relationship between body mass index and pulmonary function has been studied in many instances, not only in athletes but also in healthy and unhealthy people (Banerjee et al., 2014; Bilgin et al., 2010; Johari et al., 2017; Jones & Nzekwu, 2006; Knechtle et al., 2010; Leo, 2016). Results of these studies show that a highly positive correlation between body mass index and pulmonary function is established, but only when the body fat percent stays within the normal values, excluding people with obesity who had lower pulmonary function values with a high body mass index (A.W Permaidi & W.A Putra, 2018; Johari et al., 2017; Kalmykova Y et al., 2018) found that pulmonary function is highly linked to body mass index but also to height in triathletes. Height has been examined in some studies, always showing its relation with pulmonary function (Johari et al., 2017) and with finishing times too (Knechtle et al., 2010). Our findings only show correlation between height and pulmonary function in duathletes.

The main difference between these studies and ours is that we find different results from duathlon and long-distance triathlon, as both are comparable but have important differences because, in long-distance triathlon, athletes swim before cycling and running (Millet et al., 2003). This could be a real influence in these findings. Long-distance triathlon athletes had higher values of PEF and its body mass index is highly correlated with FVC, which is consistent with triathletes (Johari et al., 2017) and long-distance swimmers (Vogt et al., 2013). However, body mass index could have less influence in duathletes because they only perform running and cycling and swimming performance has been demonstrated to influence body mass index the most (Bilgin et al., 2010; Johari et al., 2017; Millet et al., 2003).

Apart from that, pulmonary function parameters of duathletes have a positive correlation with height, which is also consistent with findings in other studies about cycling, running or short-distance triathlon (Johari et al., 2017; Millet et al., 2003).

The importance of anthropometry is remarkable nowadays and characteristics such as height and body mass index have been demonstrated to influence exercise performance, in particular in long-distance triathlon (Knechtle et al., 2010).

Some studies only analyse males in its sample, and only Johari et al. (Johari et al., 2017) analyse both males and females in their study. Gender differences are remarkable, as male and female athletes have unequal pulmonary function parameters and anthropometric characteristics.

Differences in pulmonary function parameters are not shown in this study, as duathletes had no significant differences between genders and the sample in long-distance triathlon had only one female, so it does not make sense to carry out statistical analysis.

Duathlon athletes had significant differences in body mass index by gender. Females from this sample had lower values of body mass index than males in this modality. Similar results were demonstrated in studies (Banerjee et al., 2014; Bilgin et al., 2010; Johari et al., 2017; Jones & Nzekwu, 2006; Knechtle et al., 2010; Leo, 2016; Uth, 2005), where body mass index is shown as an indicator of performance during races and differences between males and females are remarkable depending on whether they swim, cycle or run (Leo, 2016; Millet et al., 2003).

These gender differences have been explained largely by the unequal hormonal system, which is very different between males and females. Higher testosterone levels in males may increase body muscle mass and

therefore body mass index, which provides males with more strength but also with more weight, which has both advantages and disadvantages when performing duathlon and long-distance triathlon (Ginsburg et al., 2001; Lepers & Maffiuletti, 2011; Round et al., 1999).

Both males and females in duathlon and long-distance triathlon have higher values in the pulmonary function test in comparison with healthy but non-professional athletes (Millet et al., 2003), and of course with obese people (A.W Permadi & W.A Putra, 2018; Banerjee et al., 2014; Jones & Nzekwu, 2006). Furthermore, long-distance triathlon athletes also have higher values of PEF than duathletes. As PEF is the maximum speed of expiration, this finding could be explained since long-distance triathletes perform longer distances and three different disciplines (swimming, cycling and running). Meanwhile, duathletes only perform two disciplines (cycling and running) and distances are shorter. Studies with similar findings conclude that steady and long-lasting exercises such as long-distance triathlon require higher volumes of training and very different efforts during competition, therefore pulmonary function parameters are logically unequal (Knechtle et al., 2010; Millet et al., 2003).

A study performed in ultra-endurance triathlon athletes analysed their cardiopulmonary function during competition days and found that PEF had a significant correlation with the race time (Seedhouse et al., 2006). This result is consistent with our findings in long-distance triathlon, where athletes perform longer distances than duathletes and have higher values of PEF.

The real influence of swimming in these results is difficult to compare, since complications of measuring athletes during swimming have been reported (Millet et al., 2003; Oleksiy Ganchar et al., 2018; Smith et al., 2002). However, a study performed in ultra-swimmers identified that pulmonary function parameters have higher values than ultra-runners (Vogt et al., 2013). Therefore, swimming could make the difference in long-distance triathlon when compared to duathlon.

Studies performed in long-lasting sports also reveal that gender differences are shorter in ultra-swimmers than in ultra-runners (Knechtle et al., 2010; Vogt et al., 2013). It is difficult to compare this fact with our findings because our long-distance triathlon sample has only one female and gender differences are not significant in duathletes. Samples with the same number of males and females could show differences between genders, but it is important to remark that studies performed in recent years are showing that differences between males and females in race times are decreasing (Rüst et al., 2012). Therefore, studying these differences over the years should be continued to see how their change is meaningful.

Athletes from both modalities and both genders were well-trained in all the disciplines and performed elite competitions in the ITU World Triathlon Multisport Championship in Pontevedra (2019). These findings show pulmonary function parameters and anthropometric characteristics from professional athletes. Therefore, comparison between these data and results from other athletes could be interesting in order to determine lung and anthropometric characteristics in different modalities of triathlon and with a larger sample that has the same number of males and females.

Conclusion

In conclusion, long-distance triathlon athletes have significantly higher values of PEF than duathletes. Gender does not play an important role in pulmonary function parameters, but it does in body mass index, where males have significantly higher values than females. Moreover, body mass index is correlated with FVC in long-distance triathlon athletes, and all the pulmonary function parameters are correlated with height in duathletes.

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