

## THE MORPHO-FUNCTIONAL CHARACTERISTICS OF THE RIGHT HEART IN ELITE SERBIAN TRIATHLETES

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### Abstract

Many research papers show that the most intense cardiac remodelling can be seen in endurance athletes, but no studies have examined right heart remodelling in triathletes. The aim of the study is to examine the morphological and functional characteristics of the right heart in elite Serbian triathletes. To assess the morpho-functional characteristics of the right heart, cardiac ultrasounds were performed following current recommendations, using a Philips IE33 device and a 5.2-MHz probe. The right ventricular diameter (RVEDD) was measured from the parasternal cross-section, and the right atrial volume (RA<sub>vol</sub>) and the right ventricular wall thickness (RVWT) were measured from the four-cavity cross-section. The M-mode method was used to measure the amplitude of the movement of the right ventricular tricuspid annulus (TAPSE). The sample consisted of two groups of men: experimental – elite triathlete seniors from Serbia (n=17; age: 35.88±11.27), and control – healthy untrained adults (n=20; age: 21.35±2.08). RVEDD, RA<sub>vol</sub>, and RVWT were significantly higher in the experimental group compared to the control group (p<0.01), but no significant difference was observed in TAPSE (p=0.653). Also, RVEDD and RA<sub>vol</sub> in the experimental group showed values higher than the reference values for the general population, while RVWT and TAPSE were within reference values. The obtained results indicate that there are signs of right heart remodeling in triathletes. Considering the growing number of persons involved in triathlon, it is necessary to draw the attention of all coaches and athletes to the importance of regularly monitoring the triathletes' hearts.

**Key words:** triathlon, endurance, training, cardiac remodeling, adaptation.

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## МОРФОЛОШКЕ И ФУНКЦИОНАЛНЕ КАТАКТЕРИСТИКЕ ДЕСНОГ СРЦА КОД ЕЛИТНИХ ТРИАТЛОНАЦА ИЗ СРБИЈЕ

### Апстракт

Многа истраживања показују да се најинтензивније ремоделовање срца може видети код спортиста издржљивости, али ниједно истраживање није испитало ремоделовање десног срца код триатлонаца. Циљ овог рада је да се испитају морфолошке и функционалне карактеристике десног срца код елитних триатлонаца из Србије. Да би се процениле морфо-функционалне карактеристике десног срца, урађен је ултразвук срца према актуелним препорукама, уз помоћ уређаја Philips IE33 и 5.2-MHz сонде. Дијаметар десне коморе (RVEDD) мерен је из попречног парастерналног пресека, а волумен десне преткоморе ( $RA_{vol}$ ) и дебљина зида десне коморе (RVWT) из четворошупљинског пресека. М-мод метод је коришћен за мерење амплитуде покрета трикуспидног анулуса десне коморе (TAPSE). Узорак испитаника су чиниле две групе мушкараца: експериментална – елитни триатлонци сениори из Србије ( $n=17$ ; старости:  $35,88\pm 11,27$ ), и контролна – здраве нетрениране одрасле особе ( $n=20$ ; старости:  $21,35\pm 2,08$ ). RVEDD,  $RA_{vol}$  и RVWT били су значајно већи у експерименталној групи у поређењу са контролном групом ( $p<0.01$ ), али није примећена значајна разлика у TAPSE варијабли ( $p=0,653$ ). Такође, вредности RVEDD и  $RA_{vol}$  у експерименталној групи су биле веће од референтних вредности за општу популацију, док су RVWT и TAPSE били унутар референтних вредности. Добијени резултати указују да код особа које се баве триатлоном постоје знаци ремоделовања десног срца. С обзиром на растући број триатлонаца, потребно је скренути пажњу свим тренерима и спортистима, на важност редовног праћења срца триатлонаца.

**Кључне речи:** триатлон, издржљивост, тренинг, ремоделовање срца, адаптација.

### INTRODUCTION

In physically active persons, regular intense physical activity causes adaptive changes in cardiovascular parameters, both morphological and functional (Djelić et al., 2012). These changes in the cardiovascular system that develop over time under the influence of intense and continuous physical activity are included in the term ‘athlete’s heart’ (Bjerring et al., 2019; Sanz-de la Garza, Carro, & Caselli, 2020). The role of these changes is to deliver a sufficient amount of oxygen to the active muscles during repeated high-intensity efforts (Baggish & Wood, 2011).

Many research papers demonstrate that the key factor for all the changes in the heart is the time spent on a certain type and intensity of activity (Arbab-Zadeh et al., 2014; Lewicka-Potocka et al., 2021; Popovic et al., 2011; Weiner et al., 2015). Up to date, the majority of studies analysed left heart characteristics. However, recent data demonstrates the equal importance of the right heart contribution in overall training status (Arbab-Zadeh et al., 2014; D’Ascenzi et al., 2016, 2019; Elliott & La Gerche, 2015; Sanz-de la Garza et al., 2020).

Previous research demonstrates that there is a significant difference in right ventricular and right atrial remodelling between groups of players in different team sports. It seems that right heart adaptation is the most pronounced in soccer players, who also have the highest maximal oxygen consumption (Lazic et al., 2019). Also, many research papers show that the most intense changes can be seen in athletes who use large training volumes and spend a large amount of time training and competing (cyclists, biathletes and triathletes, cross-country skiers, etc.) (Arbab-Zadeh et al., 2014; Bjerring et al., 2019; D'Ascenzi et al., 2019). Commonly, the right ventricular volumes of well-trained athletes exceed the upper limits of international guidelines, and fulfill the minor volume criteria for arrhythmogenic cardiomyopathy (D'Ascenzi et al., 2019). Also, depending on sex, the right ventricular dimension in women is lower as compared to men, independent of training status (Sanz-de la Garza et al., 2020).

It is well known that athletes performing endurance sports have an increased left ventricular mass (Lewicka-Potocka et al., 2021). Research papers show that the type of training has an impact on the type of cardiac remodelling. For example, the results of the study conducted by Arbab-Zadeh et al. (Arbab-Zadeh et al., 2014) demonstrated that endurance training at low intensity led to an increase in left ventricular mass primarily due to the increase in wall thickness (concentric hypertrophy). Then, periods of higher-intensity interval endurance training and training of longer duration led to an increase in the volume of the left ventricle and almost established the initial ratio of mass and volume (eccentric hypertrophy). In contrast, the volume and mass of the right ventricle increased simultaneously, without disturbing the mass-volume ratio (eccentric hypertrophy). Also, depending on the sport, for example, elite swimmers have a primary eccentric remodelling driven by volume, while water polo players have a higher concentric geometry indicating pressure-driven remodelling (Coates, Cheung, Currie, King, Mountjoy, & Burr, 2022). Weiner et al. examined the pattern of left ventricular change in response to short-term endurance training, followed by a maintenance phase, among 12 rowing competitors. The increase in the mass of the left ventricle in the first phase occurred exclusively due to the increase in volume, without any changes in the wall thickness of the left ventricle. In the second phase, the mass of the left ventricle was increased largely due to the increase in wall thickness (Weiner et al., 2015).

Triathlon is an endurance sport that consists of swimming, cycling, and running. Triathlon enjoys increasing popularity among competitors and recreational athletes of all ages and both genders in Serbia, as well as in the world (Strelić, Ranisavljev, Ćosić, & Stojiljković, 2022). It is one of the most demanding endurance sports and belongs to the group of Olympic sports. The Olympic Games are the biggest sports event in the world, but also a social event that brings together people from the largest number of countries in the world, promoting multicultural communication and the

concept of global peace as important factors in preserving human civilization (Šiljak, Selaković & Vukašinović, 2017). At triathlon competitions, there are distances of different lengths, but they are all equal for women and men, which is in line with the modern trend that promotes gender equality in all spheres of life, including sports. However, according to previous research, equality between women and men in sports has not yet been achieved, but it should be strived for (Vujović, Mitrović, & Obradović, 2017).

A large part of the training process of triathlon athletes is aimed at developing aerobic endurance (Cejuela & Esteve-Lanao, 2011). Besides typical long-distance aerobic training, elite triathlon athletes also devote significant training volume to high-intensity training and speed endurance work, for the development of anaerobic capacity and strength (Clemente-Suárez, Delgado-Moreno, González, Ortega, & Ramos-Campo, 2019; Pappi, Wilhelm, & Szakaly, 2022).

Studies demonstrating the phenotypical appearance of the right heart in different sports are still lacking, and there is a noted lack of studies that examine the morpho-functional changes in the right heart of endurance athletes. Since an 'athlete's heart' phenotypically resembles certain pathological conditions that can be masked by the image of an 'athlete's heart' (Haykowsky, Samuel, Nelson, & La Gerche, 2018; Nakamura & Sadoshima, 2018), it is noteworthy to assess this field in athletes who have a long record of endurance training and large training volumes, such as triathletes. Accordingly, the aim of the present study was to examine the morphological and functional characteristics of the right heart in elite Serbian triathlon athletes and to compare them with the control group and reference values for the general population.

## *METHODS*

### *Participants*

The sample consisted of two groups: experimental – triathletes, and control – untrained healthy persons. The sample of triathletes consisted of 17 elite seniors from Serbia. The inclusion criteria narrowed the sample to include participants with the following characteristics: (1.) men; (2.) older than 18 years; (3.) minimum 3 years of training experience in triathlon; (4.) minimum of 7 training hours per week (excluding strength training); and (5.) at least one placement among the first 25% placed in the absolute category, a placement in the first three places in their age category in domestic competition, or a placement in the first half of competitors in their age category in international competition, in the last 5 years.

The experimental group consisted of experienced triathlon competitors: medal winners at national championships; and participants and medal

winners at international competitions in Olympic and/or Long-distance triathlons. The control group consisted of 20 healthy untrained adult men.

### *Procedure*

The measurement for this empirical research was performed at the University Clinical Center of Serbia, and it was conducted by a cardiology subspecialist, with the assistance of a senior nurse and sports expert. To assess the morpho-functional characteristics of the right ventricle, cardiac ultrasounds were performed following current recommendations (Lang et al., 2015; Rudski et al., 2010), using a Philips IE33 device and a 5.2-MHz probe (Philips Medical Systems, Andover, MA). The cardiac ultrasound is a safe method, which does not carry any risk of adverse events.

All procedures performed in the study were approved by the Ethics Committee of the University Clinical Center of Serbia, in accordance with the ethical standards of the Helsinki declaration of 1964 and its later amendments. Informed consent was obtained from all individual participants included in the study. All participants signed a statement that they were well informed and that they voluntarily participated in the research.

The right ventricular diameter was measured from the parasternal cross-section, and the right atrial volume and the right ventricular wall thickness were measured from the four-cavity cross-section. The M-mode method was used to measure the amplitude of the movement of the right ventricular tricuspid annulus.

### *Variables*

The sample of variables is represented by indicators of morphological characteristics and systolic function of the right heart: right ventricle diameter in diastole – RVEDD; right ventricular wall thickness – RVWT; right atrial volume – RA<sub>vol</sub>; and tricuspid annular amplitude of movement in systole – TAPSE.

### *Statistical Analysis*

All variables are described by the arithmetic mean, standard deviation, minimum and maximum value, and coefficient of variation. Then, the normality of the data distribution was checked by the Kolmogorov-Smirnov and Shapiro-Wilk tests, and by visual observation of Normal Q-Q plots. The distribution of the observed data was quite normal. Due to the large difference between the average age of the experimental and control group, a one-way analysis of covariance (One-way ANCOVA) was used to explore differences between these two groups, while statistically controlling for the age variable (covariate). The non-parametric Quade's ANOVA test was performed only for the TAPSE variable, because the control group is not homogeneous (coefficient of variation 31.73%). All data

was processed in the software programmes SPSS 24 (SPSS Inc., Chicago, IL, USA) and Microsoft Office Excel 2016 (Microsoft Corporation, Redmond, WA, USA).

## RESULTS

Table 1 shows the descriptive statistics of age, anthropometric variables, and the mean resting heart rate (HR) of the experimental and control groups.

*Table 1. Descriptive statistics of the experimental (N=17) and control group (N=20)*

Variables	Experimental group				Control group			
	Mean ± SD	MIN	MAX	CV	Mean ± SD	MIN	MAX	CV
AGE (years)	35.88±11.27	23	57	31.42	21.35± 2.08	18	26	9.76
BH (m)	1.77± 0.07	1.64	1.89	3.79	1.80± 0.05	1.71	1.9	2.81
BW (kg)	73.74± 7.61	61	86.3	10.32	78.07± 7.25	65.4	92.4	9.29
BMI (kg/m <sup>2</sup> )	23.41± 2.27	20.14	28.55	9.71	24.14± 2.02	19.96	28.24	8.37
BF (%)	8.26± 3.55	2.4	17.9	43.03	12.80± 4.90	4	23.4	38.27
HR (bpm)	50.67± 7.04	37	64	13.89	76.65±11.01	58	108	14.37

Statistics: N – number of participants; Mean – average value; SD – standard deviation; MIN – minimum value; MAX – maximum value; CV – coefficient of variation. Variables: AGE – participants' age; BH – body height; BW – body weight; BMI – body mass index; BF – body fat; HR – resting heart rate.

Table 2 shows the One-way ANCOVA results for all variables (except for TAPSE, for which Quade's ANCOVA results are shown) of the morphological characteristics and systolic functions of the right heart, for both the experimental and control group.

*Table 2. Comparison of the experimental and control group results*

Variables	Experimental group		Control group		Reference value	F	p
	Mean ± SD	CV	Mean ± SD	CV			
RVEDD (cm)	2.89 ± 0.35	12.11	2.26 ± 0.32	14.16	<2.7	14.364*	0.001
RVWT (cm)	1.02 ± 0.10	9.8	0.82 ± 0.14	17.07	0.7-1.1	8.394*	0.007
RA <sub>vol</sub> (ml)	130.91 ± 30.34	23.18	82.61 ± 24.72	29.92	63-103	12.538*	0.001
TAPSE (cm)	2.41 ± 0.35	14.52	2.08 ± 0.66	31.73	>1.8	0.206	0.653

Statistics: Mean – average value; SD – standard deviation; CV – coefficient of variation; Reference value – reference value for the general population; F – one-way ANCOVA test value and Quade's ANCOVA test value for TAPSE; \* - statistical significance p<0,01. Variables: RVEDD – right ventricular end-diastolic diameter; RVWT – right ventricular wall thickness; RA<sub>vol</sub> – right atrial volume; TAPSE – tricuspid annular amplitude of movement in systole.

Based on the One-way ANCOVA results, it can be noticed that the right ventricle diameter in diastole (RVEDD) was significantly higher in

the experimental group compared to the control group ( $p=0.001$ ), and RVWT was significantly thicker ( $p=0.007$ ).  $RA_{vol}$  was also significantly higher in the experimental group compared to the control group ( $p=0.001$ ). By applying Quade's ANCOVA test to the TAPSE variable, we realised that this was the only parameter lacking a significant difference between groups ( $p=0.653$ ). RVEDD and  $RA_{vol}$  showed values higher than the reference values for the general population, while RVWT and TAPSE were within the reference values.

### DISCUSSION

The present results indicate that RVEDD,  $RA_{vol}$ , and RVWT were higher in triathletes compared to the control group. TAPSE did not differ. However, it tended to be higher in triathletes. RVEDD and  $RA_{vol}$  showed values higher than the reference for the general population, while RVWT and TAPSE were within the reference values.

The variables with the highest level of difference are primary variables that describe the morphological characteristics of the right heart (RVEDD,  $RA_{vol}$ , and RVWT), while the variable describing the systolic function of the right heart did not indicate a significant difference between the experimental and control groups. These results coincide with the statements made by D'Ascenzi et al., who also noted that systolic function in well-trained athletes did not change in comparison to the general population, despite all the morphological changes characteristic of the 'athlete's heart' (D'Ascenzi et al., 2019).

The values of the RVWT indicate a significant difference between the experimental and control groups. Although the values did not go beyond the reference values for the general population, they were close to the upper normal limit. Thus, they did not exceed the limit that is considered pathological which would characterise hypertrophic cardiomyopathy (Nakamura & Sadoshima, 2018; Sanz-de la Garza et al., 2020).

The values of RVEDD in our study were  $2.89\text{cm} \pm 0.35\text{cm}$ , and it was significantly higher in the experimental group compared to the control group ( $p<0.01$ ). In the research of Popović et al. (Popovic et al., 2011), values for this variable were  $2.62\text{cm} \pm 0.44\text{cm}$  for the water polo group, and  $2.53\text{cm} \pm 0.51\text{cm}$  for the wrestler group. When comparing the results of these two studies, it can be observed that the values of RVEDD in athletes who practice different types of training are different. This gradation of results indicates a more intensive remodelling of the right heart due to the increasing demands of endurance sports. In a study conducted by Popović et al. (Popovic et al., 2011), changes in morphology and heart function were examined by taking water polo players and wrestlers as experimental groups and comparing the values yielded by these groups with the values in the control group. The results indicated that changes in systolic function

occurred in both groups of athletes compared to the control group, but that the changes were more pronounced in wrestlers. The possible cause of this finding could be the greater explosive force of the entire musculature of the wrestler, which is also reflected in the adaptation of the heart muscle. This result supports the opinion that sports in which the volume of training load predominates can cause a slight decrease in right ventricular systolic function (primarily due to the reduced resting heart rate). Also, the same results show that the type and intensity of changes that occur in the heart depend on the type of physical activity.

Present results showed that the value of RVWT in triathletes was  $1.02\text{cm} \pm 0.1\text{cm}$ , and it was significantly higher than in the control group. The results of the study conducted by Yilmaz et al., where morphological and functional changes in the heart of male and female athletes (football, hockey, running, swimming, and gymnastics) were compared with the sedentary population, indicated that athletes have a greater wall thickness compared to untrained subjects (Yilmaz, Buyukakilli, Gurgul, & Rencuzogullari, 2013). In men, the values for this variable were  $0.96\text{cm} \pm 0.10\text{cm}$ , which is a lower value compared to the same variable in our study. This difference could be caused by the higher average volume of training performed by triathletes.

The results of the present study show that the average value of TAPSE was  $2.41\text{cm} \pm 0.35\text{cm}$ , and it was the only parameter where no significant difference was observed between the experimental and control group. Also, there were indications that the acute reaction to prolonged exercise was associated with a decrease in the systolic function of the right ventricle, while the left one had almost no changes (Elliott & La Gerche, 2015). In the meta-analysis of D'Ascenzi et al., the average value of the TAPSE variable was 2.5cm in athletes trained in both endurance and strength types, as well as combined (D'Ascenzi et al., 2017). We can assume that these values were higher than the values in our study probably because triathletes were exposed to a larger volume of training compared to the average athletes in endurance sports.

The average value of  $RA_{\text{vol}}$  in our study was  $130.91\text{ml} \pm 30.34\text{ml}$ , and it was significantly higher in the experimental group compared to the control group. Kawel-Boehm et al. reported values for the right atrial volume of healthy adults averaging  $103\text{ml} \pm 33\text{ml}$  (Kawel-Boehm et al., 2015). Compared to these values, our group of triathletes recorded almost 30% higher values, which confirms our hypothesis that significant signs of changes in the morphology of the right heart occur through endurance training.

Greater morphological and less functional changes of the right ventricle to the left ventricle in athletes may be attributed to greater resistance in the lung in comparison to systemic circulation (Milutinović et al., 2018). The intensity of morphological changes increases with training intensity (ibid.). Therefore, athletes who are engaged in endurance sports that require



a large volume and large intensity of training have the greatest morphological changes in the right heart (triathlon, cycling, mid/long distance running, rowing, etc.) (Adea et al., 2020; D'Ascenzi et al., 2019). All of the above show the fact that heart adaptation to chronically increased physical stress is an extremely complex process with a very narrow 'adaptive window' which increases work efficiency. All non-physiological stimuli in the training process (overtraining, dehydration, doping, etc.), further complicate these mechanisms and can very easily turn them in a pathological direction, with potentially fatal consequences (Milutinović et al., 2018; Vanova et al., 2022).

An 'athlete's heart' phenotypically resembles certain pathological conditions, that can be masked by the image of an 'athlete's heart', but the key difference is the reversibility of changes (Haykowsky et al., 2018; Nakamura & Sadoshima, 2018). In a simple deconditioning test, pathological changes will progress, whereas most of the changes in the 'athlete's heart' tend to return to baseline values, without progression to heart failure (Haykowsky et al., 2018; Nakamura & Sadoshima, 2018). Moreover, adaptation due to poorly programmed training, non-compliance with basic principles in the training process, use of illicit substances, among others, may turn physiological adaptation into a pathological condition (Levine, Baggish, Kovacs, Link, Maron, & Mitchell, 2015). Considering that the cause of sudden cardiac death of athletes was often diagnosed with hypertrophic cardiomyopathy (Cunningham, Spears, & Care, 2019; Kochi, Vettor, Dessanai, Pizzamiglio, & Tondo, 2021; Maron et al., 2019; Weissler-Snir et al., 2019), and most cardiac pathologies are silent (Mont et al., 2017), it is important to regularly monitor 'athlete's hearts' (Corrado et al., 2005; Mont et al., 2017; Vanova et al., 2022).

### CONCLUSION

The obtained results indicate that there are signs of right heart remodelling in triathletes compared with the untrained population, and concerning reference values for the general population. Changes that have been observed appear as an adaptation to chronic exposure to long-term physical exertion, in order to increase cardiac work efficiency in stress conditions. As the number of people involved in triathlon is constantly growing, it is clear that the number of people affected by a certain degree of changes in the heart muscle is growing, especially since recreational athletes strive for almost the same training loads as professional athletes. Therefore, it is necessary to draw the attention of all coaches and athletes to the importance of the regular examination and monitoring of every 'athlete's heart'.

The results of this research can be used as an indicator of what morphological and functional changes can be expected as a result of long-term triathlon training. Moreover, these results may represent the first step towards establishing reference values of RVEDD and RA<sub>vol</sub> in triathletes. To

establish these values, further research on a larger sample of participants is necessary. Reference values would make it easier for sports medicine doctors, coaches, and athletes to interpret specific right heart parameters in each triathlete.

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## МОРФОЛОШКЕ И ФУНКЦИОНАЛНЕ КАТАКТЕРИСТИКЕ ДЕСНОГ СРЦА КОД ЕЛИТНИХ ТРИАТЛОНАЦА ИЗ СРБИЈЕ

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### Резиме

Већина досадашњих истраживања анализирала је карактеристике леве срчане коморе код спортиста, али новији подаци показују једнак значај доприноса десног срца у укупном тренажном статусу. Многа истраживања показују да се најинтензивније ремоделовање срца („спортско срце“) може видети код спортиста који се баве спортовима издржљивости. Међутим, ниједно истраживање није испитало карактеристике десног срца код особа које се дужи временски период баве триатлоном. Триатлон је олимпијски спорт који ужива све већу популарност у Србији и у свету. Спада у групу спортова дуготрајне издржљивости, а састоји се из пливања, вожње бицикла и трчања на дистанцама различите дужине. Циљ овог рада је био да се испитају морфолошке и функционалне карактеристике десног срца код елитних триатлонаца из Србије. Да би се процениле морфо-функционалне карактеристике десног срца, урађен је ултразвук срца према актуелним препорукама, користећи уређај Philips IE33 и сонду од 5,2-MHz (Philips Medical Systems, Andover, MA). Дијаметар десне коморе (RVEDD) мерен је из попречног парастерналног пресека, а волумен десне преткоморе (RA<sub>vol</sub>) и дебљина зида десне коморе (RVWT) из четворошупљинског пресека. М-мод метод је коришћен за мерење амплитуде покрета трикуспидног анулуса десне коморе (TAPSE). Узорак испитаника су чиниле две групе мушкараца: експериментална – елитни триатлонци сениори из Србије (n=17; старости: 35,88±11,27) и контролна – здраве

нетрениране одрасле особе ( $n=20$ ; старости:  $21,35\pm 2,08$ ). Једносмерна АНКОВА је коришћена за испитивање разлика између две групе, док је статистички контролисана варијабла старости. Само за TAPSE варијаблу је урађен непараметарски тест (Quade's ANOVA), јер контролна група није била хомогена. RVEDD, RVWT и  $RA_{vol}$  су били значајно већи ( $p<0.01$ ) у експерименталној групи ( $2,89\pm 0,35\text{cm}$ ;  $1,02\pm 0,10\text{cm}$ ;  $130,91\pm 30,34\text{ml}$ ) у поређењу са контролном групом ( $2,26\pm 0,32\text{cm}$ ;  $0,82\pm 0,14\text{cm}$ ;  $82,61\pm 24,72\text{ml}$ ). Није примећена значајна разлика ( $p=0,653$ ) између TAPSE варијабле у експерименталној ( $2,41\pm 0,35\text{cm}$ ) и контролној групи ( $2,08\pm 0,66\text{cm}$ ). Такође, RVEDD и  $RA_{vol}$  код експерименталне групе, показују вредности веће од референтних вредности за општу популацију, док су RVWT и TAPSE унутар референтних вредности. Добијени резултати указују да код особа које се баве триатлоном постоје знаци ремоделовања десног срца у односу на нетрениране особе и референтне вредности за општу популацију. Наиме, највећу разлику између експерименталне и контролне групе у нашем истраживању су имале варијабле које описују морфолошке карактеристике десног срца (RVEDD,  $RA_{vol}$  и RVWT), док код варијабле која описује систолну функцију (TAPSE) није било значајне разлике. Добијени резултати су у складу са резултатима претходних истраживања у којима је такође забележено да је код утренираних спортиста у спортовима издржљивости дошло до значајних морфолошких промена карактеристичних за „спортско срце“, док се систолна функција није значајно променила у односу на општу популацију. С обзиром да број људи који се баве триатлоном константно расте, а патолошко стање срца може бити прикривено иза „спортског срца“, потребно је скренути пажњу свим тренерима и спортистима, на важност редовног праћења срца сваког триатлонца. Резултати овог истраживања могу представљати први корак ка успостављању референтних вредности варијабли RVEDD и  $RA_{vol}$  код триатлонаца. Да би се ове вредности дефинисале, потребна су даља истраживања на већем узорку испитаника.