Available online at www.medicinescience.org

ORIGINAL ARTICLE

Medicine Science 2021;10(4):1293-8

How do different types of physical activity affect echocardiography findings and heart rate variability in children?

Ahmet Selman Guldagi[1], Ayhan Pektas[1], Mehmet Celegen[1], Mehmet Bilgehan Pektas[2]

[1]Afyonkarahisar Health Sciences University, Faculty of Medicine, Department of Pediatrics, Afyonkarahisar, Turkey
[2]Afyonkarahisar Health Sciences University, Faculty of Medicine, Department of Medical Pharmacology, Afyonkarahisar, Turkey

Received 01 May 2021; Accepted 01 June 2021
Available online 09.2021 with doi: 10.5455/medscience.2021.05.150

Abstract

This study aims to investigate how different types of regular physical activity affect cardiac function in school children. This is a cross-sectional review of 15 children who are not engaged with any regular physical activity (controls) and 60 athletes who swim (n=15), play basketball (n=15), play volleyball (n=15), and play tennis (n=15) regularly. The children who are not engaged with any sports, the children who swim, and the children who play basketball, volleyball and tennis are statistically similar with respect to age, sex, height, weight and body mass index (p>0.05 for all). When compared with the controls and other athletes, the swimmer children have significantly higher left ventricle diastolic mass, higher left ventricle posterior wall systolic thickness, lower mitral A wave, higher mitral annular plane systolic excursion and higher mitral E/A ratio (p=0.006, p=0.035, p=0.030, p=0.025 and p=0.043 respectively). The swimmer children have significantly lower interventricular septum E and A waves and significantly longer left ventricle IVRT than the controls and other athletes (p=0.0[illegible], p=0.040 and p=0.004 respectively). When compared with the controls and other athletes, the swimmer children have significantly lower p-wave dispersion and QT dispersion values (p=0.038 and p=0.035 respectively). The swimmer children have significantly higher total power and SDNN values than the controls and other athletes (p=0.046 and p=0.026 respectively). Swimming might contribute to the growth of cardiac muscles and help to improve the cardiac conduction system and enhance parasympathetic innervation of the heart in children.

Keywords: Child, echocardiography, electrocardiography, heart rate variability, sports

Introduction

Heart rate variability (HRV) is defined as the variation in the time interval between consecutive heartbeats in milliseconds. This physiological phenomenon designates the autonomic innervation of the heart, indicating the current status of wellbeing and long term health consequences (Cygankiewicz and Zareba, 2013; Xhyheri, Manfrini and Mazzolini, 2021). It has been reported that a decrease in HRV might predict mortality after myocardial infarction (Sen and McGill 2018; Brateanu, 2015). Decreased HRV can be also associated with diabetic neuropathy, cardiac transplantation and sudden cardiac death (Islam, Kim and Lee, 2018; Lin et al., 2017; Sessa et al., 2018).

It has been hypothesized that interventions that increase HRV may be protective against cardiac mortality and sudden cardiac death. These interventions consist of beta-adrenergic blockade, anti-arrhythmic drugs, muscarinic receptor blockers, thrombolysis and physical activity (Kuryanova, Tryasuchev and Stupin, 2017; Kuryanova, Tryasuchev and Stupin, 2018, Larosa et al., 2005). Amongst these, regular physical training might contribute to cardiac health by modulating the autonomic functions. A body of evidence for this hypothesis is the "training bradycardia" of the individuals who do physical exercises routinely (Larosa et al., 2005; Besnier et al., 2017; Doyen, Matelot and Carré, 2019).

As for the young adults, studies focusing on the impact of physical activity on HRV have yielded discrepant outcomes (Sandercock, Bromley and Brodie, 2005). A study that has examined the effects of physical activity habits in different age groups is unable to report significant results in young adults (Prodel et al., 2017). On the other hand, similar studies have demonstrated that the adolescents who are physically active have greater HRV than their sedentary counterparts (Kaikkonen et al., 2014; Felber Dietrich et al., 2008; Sharma, Subramanian and Arunachalam, 2015; Henje

*Corresponding Author: Mehmet Bilgehan Pektas, Afyonkarahisar Health Sciences University, Faculty of Medicine, Department of Medical Pharmacology, Afyonkarahisar, Turkey, E-mail: mbpektas@gmail.com

Blom, Olsson and Serlachius, 2009). Additionally, it has been shown that autonomic cardiovascular regulation is improved in obese adolescents who have been engaged in regular physical training (Lucini et al., 2013; Nagai and Moritani, 2004). However, the major limitation of these studies is the negligence of different types of physical activity. That is, either individual or team sports were considered as one type of physical activity. Moreover, some studies evaluated just total physical activity (Kaikkonen et al., 2014; Felber et al., 2008) and other studies assessed leisure-time physical activity (Sharma et al., 2015; Lucini et al., 2013; Nagai and Moritani, 2004). This study aims to investigate how different types of regular physical activity affect echocardiography findings and heart rate variability in school children.

Materials and Methods

The parents of all participants were informed about the study and their written informed consents were obtained for the participation of their children. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Afyonkarahisar Health Sciences University (grant no: 2019/1-10).

This is a cross-sectional review of 15 children who were not engaged with any regular physical activity or sports (controls) and 60 athletes who swam (n=15), played basketball (n=15), played volleyball (n=15), and played tennis (n=15) regularly. An athlete has been identified as a student, beginning from the age of 7 years, who routinely participates in sporting events like matches, games, and tournaments and undergoes supervised physical conditioning training for a minimum of 25 hours a week or does vigorous intensity physical activity exercises to achieve physical strength, speed and/or endurance exercises for at least 30 minutes per day, three times a week (Coe, 2014; WHO, 2011; Fox, 2011). This study has been designed to investigate the benefits of different physical activity types on echocardiography findings and heart rate variability of the athlete children. That's why children who belonged to the same age group but vigorously involved in different physical activities were recruited to make up the study groups.

The children with cardiovascular diseases, diabetic children, the children with neurological disorders and handicapped children were excluded. The use of alcohol, tobacco, and/or other drugs; consumption of caffeine 12 hours preceding the HRV analysis and performing any physical exercise 24 hours before the clinical evaluations were the other exclusion criteria.

Data related with age, sex height and weight are recorded. Body mass index (BMI) is computed as follows: Body mass index= Weight (kg) / Height^2 (m^2)

Echocardiography examination

Echocardiography examination was made by using equipment with 3-5 MHz transducers (Vivid I, GE Healthcare, Chicago, IL, USA). The patients were made to rest for 5 minutes before the measurements and breathe slowly throughout the procedure. Recordings were performed with subjects in the supine or left lateral positions. All children underwent M-mode, Doppler-continuous and pulse wave-echocardiography examination.

M-mode tracings were obtained at the level of the tips of mitral leaflets in the parasternal long-axis position, and measurements of the left ventricular end-systolic and end-diastolic dimension were performed according to the recommendations of the American Society of Echocardiography (Nagueh et al., 2016). Left ventricular end-systolic and end-diastolic dimensions as well as aorta and interventricular septum dimensions were measured from the parasternal long-axis window. Left ventricular ejection fraction and fractional shortening were provided using Teichholtz in M-mode echocardiography.

Tissue Doppler measurements were performed to measure the myocardial velocities during systole, early diastole and late diastole. The isovolumic contraction time (IVCT) was the time period between the end of the myocardial wave during late diastole (Am) and the beginning of the myocardial wave during systole (Sm). The isovolumic relaxation time (IVRT) was the time period between the end of the Sm wave and the beginning of the myocardial wave during early diastole (Em). Ejection time was the duration of ventricular outflow. Myocardial performance index (MPI) was the sum of IVCT and IVRT values, divided by ejection time.

The mean values were recorded by averaging the results of three consecutive measurements.

Electrocardiography evaluation

All children had 12-lead electrocardiography (ECG) which was scanned at a paper speed of 50 mm/hour and gain of 10 mm/mV (Cardiofax V; Nihon Kohden Corporation, Tokyo, Japan) in supine position. The patient was allowed to breathe spontaneously, but speaking was not permitted during the recording. All measurements were done manually by using magnifying glass and the mean values were recorded by averaging three consecutive measurements.

The electrical axis of the heart in the frontal plane was represented by the QRS-axis. P-wave duration was measured in lead II, from the beginning to the end of P-wave. PR interval was also measured in lead II, from the beginning of P-wave to the beginning of R-wave. QRS complex duration was measured in lead V, from the beginning of Q wave to the end of the S wave. The measurement of the QT interval was started from the onset of the QRS complex until the end of the T-wave. Corrected QT interval was specified by Bazett's formula (Bazett, 1920). P-wave dispersion was calculated by subtracting minimum P-wave duration from maximum P-wave duration. QRS dispersion was the difference between maximum and minimum QRS complex durations. Corrected QT dispersion was found by subtracting minimum corrected QT interval from maximum corrected QT interval. T-peak to T-end interval was measured as the distance between the peak and end of T wave.

Heart rate variability analysis

Holter monitoring was performed for 24 hours by means of a digital monitor (DL800, Compact Flash Card Holter Recorder, Minnesota, USA). Holter monitoring was started between 8 and 9 a.m. during the working days of the week and all patients were asked to continue their normal daily activities during the test days. In order to specify HRV parameters, the data stored were processed by Holter software (Cardiolight FMC.A, Medizintechnik,

Hamburg, Germany). Before HRV analyses were performed, the precision of computer-assisted methods was provided and ectopic beats, noisy data, and artifacts were identified and excluded from the analysis. All Holter recordings were interpreted by the same investigator (A.P.). At least 21 hours of analyzable signals with a less than 2 hours difference between consecutive recordings were analyzed using the time-domain method. The parameters analyzed included standard deviation of all the adjacent NN intervals (SDNN), standard deviation of the averages of NN intervals in all 5-min segments (SDANN), square root of the mean of the sum of the squares of the differences between adjacent NN intervals (RMSSD) and geometric measure of the integral of the density of the RR interval histogram divided by its height (triangular index).

Statistical analysis

Collected data were analyzed by Statistical Package for Social Sciences version 20.0 (SPSS Inc., SPSS IBM, Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (range: minimum-maximum) and categorical variables were denoted as numbers or percentages. Kolmogorov-Smirnov test was used to test the distribution of data while Mann Whitney U test and Wilcoxon test were used for the comparisons. Two-tailed p values less than 0.05 were accepted to be statistically significant.

Results

Table 1 shows the demographic characteristics of the participants. The children who are not engaged with any sports, the children who swim, and the children who play basketball, volleyball and tennis are statistically similar with respect to age, sex, height, weight and BMI (p>0.05 for all). Table 2 demonstrates the echocardiography findings of the participants. When compared to the controls and other athletes, the children who swim have significantly higher left ventricle diastolic mass, higher left ventricle posterior wall systolic thickness, lower mitral A wave, higher mitral annular plane systolic excursion and higher mitral E/A ratio (p=0.006, p=0.035, p=0.030, p=0.025 and p=0.043 respectively). Table 3 displays the tissue Doppler echocardiography findings of the participants. The children who swim have significantly lower interventricular septum E and A waves and significantly longer left ventricle IVRT than the controls and other athletes (p=0.001, p=0.040 and p=0.004 respectively). Table 4 summarizes the electrocardiography findings of the participants. When compared with the controls and other athletes, the children who swim have significantly lower p-wave dispersion and QT dispersion values (p=0.038 and p=0.035 respectively). Table 5 enlists the heart variability of the participants. The children who swim have significantly higher total power and SDNN values than the controls and other athletes (p=0.046 and p=0.026 respectively).

Table 1. Demographic characteristics of the participants

	Basketball (n=15)	Volleyball (n=15)	Swimming (n=15)	Tennis (n=15)	Controls (n=15)	p
Age (years)	12.0±1.9	12.6±2.2	10.7±1.5	10.6±1.4	11.3±1.8	0.688
Male/Female	9-6 (60%-40%)	5-10 (33.3%-66.7%)	8-7 (53.3%-46.7%)	9-6 (60%-40%)	8-7 (53.3%-46.7%)	0.577
Height (cm)	155.2±28.4	159.4±31.6	149.1±24.7	148.9±22.3	149.4±25	0.133
Weight (kg)	46.9±3.5	53.5±4.2	40.3±2.6	43.2±3.1	52.3±4	0.452
BMI (kg/m²)	19.4±1.7	20.7±2.1	17.9±1.2	19.3±1.8	23.4±2.2	0.379

BMI: body mass index

Table 2. Echocardiography findings of the participants

	Basketball (n=15)	Volleyball (n=15)	Swimming (n=15)	Tennis (n=15)	Controls (n=15)	p
Ejection fraction	74.4±1.9	75.2±1.8	75.9±1.7	71.6±1.9	73.3±1.5	0.573
Fractional shortening	45.2±2.1	44.1±1.7	44.4±1.8	40.5±1.7	43.2±.6	0.226
Systolic volume	54.6±4.2	59.8±5.4	54.2±3.1	49.7±3	55.7±4.8	0.189
End-diastolic volume	72.6±4.1	77.8±7.2	71.4±3.6	69.9±3.4	74.5±6.3	0.344
Left ventricle systolic mass	119.8±10.7	121.7±11.1	112.3±11.6	102.8±6.3	114.5±9.2	0.189
Left ventricle diastolic mass	130.5±2.1	109.2±6.8	138.7±9.9	124.8±10.4	128.6±8.4	0.006*
LVPW systolic thickness	1.58±0.2	1.60±0.3	1.62±0.3	1.50±0.1	1.38±0.1	0.035*
LVPW diastolic thickness	0.91±0.1	0.94±0.04	0.88±0.1	0.89±0.01	0.92±0.02	0.804
Mitral E wave	1.19±0.06	1.1±0.06	1.1±0.1	1.13±0.1	1.15±0.04	0.292
Mitral A wave	0.7±0.03	0.72±0.04	0.59±0.04	0.62±0.03	0.75±0.05	0.030*
Mitral E/A ratio	1.76±0.1	1.55±0.09	1.9±0.1	1.84±0.1	1.88±0.08	0.043*
Tricuspid E wave	0.82±0.07	0.78±0.04	0.7±0.05	0.78±0.1	0.8±0.06	0.361
Tricuspid A wave	0.47±0.04	0.48±0.02	0.4±0.04	0.48±0.03	0.5±0.02	0.315
Tricuspid E/A	1.78±0.1	1.68±0.08	1.81±0.1	1.66±0.1	1.77±0.06	0.513
TAPSE	3.77±0.15	3.99±0.21	3.8±0.17	3.64±0.2	3.82±0.24	0.567
MAPSE	3.33±0.1	3.16±0.14	2.89±0.2	2.9±0.2	3.54±0.2	0.025*

LVPW: left ventricle posterior wall, TAPSE-MAPSE: tricuspid-mitral annular plane systolic excursion, *p<0.05 was accepted to be statistically significant

Table 3. Tissue doppler echocardiography findings of the participants

	Basketball (n=15)	Volleyball (n=15)	Swimming (n=15)	Tennis (n=15)	Controls (n=15)	p
Left ventricle E wave	0.2±0.01	0.19±0.01	0.19±0.01	0.21±0.01	0.20±0.01	0.312
Left ventricle A wave	0.08±0.01	0.08±0.01	0.1±0.01	0.1±0.01	0.09±0.01	0.782
Left ventricle S wave	0.12±0.01	0.11±0.01	0.11±0.01	0.11±0.01	0.10±0.01	0.424
Left ventricle MPI	44.7±3.1	42.2±1.3	40.3±1.6	47.1±3.4	46.4±2.5	0.946
Left ventricle IVRT (ms)	56.9±2.4	53.0±2.7	60.9±2.5	59.7±3.8	55.4±2.3	0.001*
Left ventricle IVCT (ms)	56.9±3.2	53.7±2.3	52.5±3.3	53.2±2.4	52.6±2.8	0.390
Interventricular septum E wave	0.14±0.01	0.15±0.01	0.13±0.01	0.16±0.01	0.18±0.01	0.040*
Interventricular septum A wave	0.08±0.01	0.11±0.01	0.07±0.01	0.09±0.01	0.11±0.01	0.004*
Interventricular septum S wave	0.08±0.01	0.09±0.01	0.1±0.01	0.14±0.01	0.15±0.01	0.362
Interventricular septum MPI	45.4±2.6	47.6±1.9	44.1±1.7	43.7±1.6	46.1±2.5	0.525
Interventricular septum IVRT (ms)	55.1±2.6	56.4±3.1	58.7±2.9	58.4±2.6	57.3±2.8	0.309
Interventricular septum IVCT (ms)	57.7±2.1	58.5±2.1	57.7±2.6	54.9±2.1	59.1±3.2	0.440
Right ventricle E wave	0.17±0.01	0.18±0.01	0.17±0.01	0.19±0.01	0.2±0.02	0.846
Right ventricle A wave	0.12±0.01	0.12±0.01	0.11±0.01	0.13±0.01	0.14±0.01	0.653
Right ventricle S wave	0.13±0.01	0.13±0.01	0.14±0.01	0.15±0.01	0.14±0.01	0.170
Right ventricle MPI	48.9±2.5	51.4±3.9	48.4±2.9	49.3±2.7	50.5±3.0	0.906
Right ventricle IVRT (ms)	58.3±2.2	60.1±2.6	59.7±2.3	62.0±3.1	61.1±2.8	0.742
Right ventricle IVCT (ms)	60.8±3.7	57.4±2.8	53.3±2.2	61.2±2.6	62.0±3.1	0.263

MPI: myocardial performance index, IVRT-IVCT: isovolumic relaxation-contraction time
*p<0.05 was accepted to be statistically significant

Table 4. Electrocardiography findings of the participants

	Basketball (n=15)	Swimming (n=15)	Tennis (n=15)	Volleyball (n=15)	Controls (n=15)	p
Heart rate	89.6±0.8	83.9±3.7	85.1±4.1	85.6±3.1	86.1±3.5	0.582
p-wave duration	62.3±2.3	63.9±1.9	61.9±1.8	66.4±2.2	65.6±2.1	0.407
p-wave dispersion	42.9±2.7	38.7±1.3	48.6±4.5	42.5±3.1	45.2±3.3	0.038*
PR interval	114.4±4.7	120.1±4.6	117.3±4.1	121.5±5.4	122.7±6.1	0.673
QRS complex duration	69.7±3.8	73.8±3.9	75.9±4.5	75.2±2.4	77.4±3.6	0.547
QT interval	334.6±6.2	336.9±6.1	343.6±5.4	328.4±4.6	346.5±6.1	0.104
QT dispersion	64.3±5.2	60.3±4.9	62.9±6.2	68.8±7.1	70.7±5.4	0.035*
Corrected QT interval	389.1±6.7	394.4±4.9	408.3±8.4	397.2±5.1	394.7±8.1	0.190
Corrected QT dispersion	81.9±8.6	80.1±5.5	88.2±8.5	92.6±8.4	86.6±7.7	0.721
T-peak to T-end interval	64.1±2.3	64.0±2.3	62.3±1.6	65.6±2.7	64.2±1.9	0.453

*p<0.05 was accepted to be statistically significant

Table 5. Heart rate variability of the participants

	Basketball (n=15)	Swimming (n=15)	Tennis (n=15)	Volleyball (n=15)	Controls (n=15)	p
Total power	4505.5±775.6	5019.3±663.4	2689.1±433.1	3728.5±529.3	1788.9±387.5	0.046*
VLF	2754.4±605.3	3277.7±465.9	2057.9±224.1	2446.5±356.1	1556.4±326.4	0.196
LF	972.7±112.4	979.5±125.4	663.5±116.6	752.8±118.2	546.3±96.3	0.140
HF	528.5±91.7	707.9±97.7	422.7±101.8	479.4±82.6	249.2±57.5	0.115
LF/HF ratio	2.2±0.2	1.6±0.2	2.1±0.3	1.7±0.1	2.2±0.4	0.208
SDNN (msec)	144.7±10.9	153.9±9.1	106.5±11.2	137.5±12.1	79.6±8.5	0.026*
SDANN (msec)	132.8±10.4	141.1±10.3	97.5±13.4	123.5±11.9	84.3±9.2	0.079
SDNN index	66.6±5.5	72.3±4.9	56.8±3.2	62.6±4.3	55.1±2.8	0.108
RMSSD	50.3±6.8	52.5±4.2	45.3±4.8	48.2±4.4	37.6±3.5	0.671
PNN50	24.1±4.7	26.1±2.7	21.4±3.9	22.3±2.8	19.1±2.2	0.662

*p<0.05 was accepted to be statistically significant

Discussion

Physical activity is an important factor in the establishment and maintenance of good health. That's why; World Health Organization recommends structured physical activity for both children and adolescents (Fox, 2011; WHO, 2011). Beneficial effects of physical activity on cardiorespiratory health have been reflected by attenuated heart rate and increased oxygen consumption during exercise (Felber et al., 2008; Lavie, Church and Milani, 2011).

Children dealing with sports have significantly lower resting heart rate than the children with sedentary lifestyle because they have larger hearts in size and higher stroke volumes (Sharma et al., 2015). Decreased heart rate in association with increased stroke volume leads to a rise in maximum oxygen consumption because the highest heart rates recorded during exercise are similar in physically active and sedentary individuals (Sharma et al., 2015; Lavie et al., 2011).

In fact, heart rate is the result of a balance between sympathetic and parasympathetic nervous activities. Parasympathetic nervous activity is enhanced and sympathetic nervous activity is weakened in individuals who have good cardiorespiratory health status (Besnier et al., 2017). One reason for the enhancement in parasympathetic activity is vigorous exercise as it has been shown that doing physical activity for three months improves vagal activity (Sandercock et al., 2005). Regular physical training might induce repetitious stimulation of sympathetic activity, which is followed by deactivation of sympathetic activity and reciprocal acceleration in parasympathetic activity subsequently (Kaikkonen et al., 2014).

The HRV analysis has been adopted as a non-invasive and practical technique which can be used to assess the activity of autonomic nervous system and, more specifically vagal activity, by means of different time and frequency domain measures. This technique allows the investigation of short and long term health consequences and monitorization of performance in athletes (Pichot, Laursen and Stanley et al., 2013). However, studies focusing on the HRV analysis of children/adolescents dealing with sports are still scanty in number and yield controversial results (Moraes et al., 2019; Sharma et al., 2017).

It has been reported that all parameters of HRV can be used to predict mortality or transplantation in a cohort of children with severe pulmonary hypertension (Lammers et al., 2010). Another study claimed that total cavopulmonary connection leads to a significant reduction in overall cardiac autonomic tone which had been interpreted as a good prognostic factor for children undergoing univentricular heart repair (Madan et al., 2014). Similarly, a Turkish study found that transcatheter closure of secundum atrial septal defect improves HRV which reduces morbidity and improves prognosis (Özyılmaz et al., 2016).

Swimming is a popular physical activity which may help to reduce pain and alleviate psychological symptoms (Tian et al., 2018; Maged et al., 2016). Prior research has highlighted the benefits of swimming in the prevention and treatment of cardiovascular diseases (Jualnim et al., 2012; Tanaka, 2009).

Several studies have described the adaptive remodeling of the heart in swimmers. Swimming in prone position accelerates venous blood flow to the right atrium and ventricle which subsequently causes a disproportionate increase on the load of the right ventricle. This may lead to an acute dilatation in right ventricle but this dilatation is not usually associated with the dysfunction of right ventricle (D'Andrea et al, 2015; Martinez et al., 2019; Shoemaker et al., 2019). Prior research has specified that individuals who regularly train swimming have left ventricular dilatation, normal wall thickness to dimension ratio and increased stroke volume with normal diastolic filling (Lazar, Khanna and Chesler, 2013). In contrast, this study found that the swimmer children who had significantly higher left ventricle diastolic mass, significantly higher posterior wall systolic thickness, significantly lower mitral A wave and significantly lower interventricular septum E and A waves. Such discrepancy might be attributed to the relatively small cohort size, lack of longitudinal data and technical variations in the measurement and recording of echocardiography, ECG and HRV parameters.

P wave dispersion has been addressed as a marker for atrial remodeling and as an indirect predictor for atrial fibrillation. Increased p wave dispersion reflects the delay in intra-atrial and inter-atrial conduction time and this delay can be due to the lack of a well coordinated conduction system within the atrial muscles (Izci et al., 2015). QT dispersion is an electrocardiography parameter which depends on the heterogeneity of repolarization. This marker might be used to predict ischemia related cardiac dysrhythmias in patients with ischemic heart diseases (Izci et al., 2015). Accordingly, this study specified the significant reduction in p-wave dispersion and QT dispersion values of the swimmer children.

The SDNN is a time-domain measurement which is accepted as the "gold standard" for identifying the risk of cardiac morbidity and mortality when it has been recorded over a period of 24 hours (Shaffer and Ginsberg, 2017). Total power is a frequency-domain measurement which refers to overall autonomic activity to which sympathetic activity contributes primarily (Shaffer and Ginsberg, 2017). An animal study has concluded that parasympathetic activity is the possible physiological mechanism for the resting bradycardia determined in swimmers (Medeiros et al., 2004). Complying with literature, the children who trained swimming in this study had significantly higher total power and SDNN values than the controls and other athletes.

Conclusion

Swimming is a physical activity type which can be practiced by children and young adults. This activity differs from other sports as it is related with prone positioning and immersion in water. The alterations in echocardiography, electrocardiography and HRV measurements of the swimmer children suggest that this sport might contributes to the growth of cardiac muscles, improve the cardiac conduction system and enhance parasympathetic innervation of the heart in children. However, the findings of the present study should be interpreted carefully as their power is limited by the cross-sectional study design, relatively small cohort size and lack of longitudinal data. Further research is warranted to clarify the effects of regular training in different physical activity modalities on the cardiac well being of children and adolescents.

Conflict of interests
The authors declare that they have no competing interests.

Financial Disclosure
All authors declare no financial support.

Ethical approval
The study was approved by the Ethics Committee of Afyonkarahisar Health Sciences University (grant no: 2019/1-10).

References

1. Bazett HC. The time relations of the blood-pressure changes after excision of the adrenal glands, with some observations on blood volume changes. J Physiol. 1920;53:320-39.
2. Besnier F, Labrunée M, Pathak A, et al. Exercise training-induced modification in autonomic nervous system: An update for cardiac patients. Ann Phys Rehabil Med. 2017;60:27-35.
3. Brateanu A. Heart rate variability after myocardial infarction: what we know and what we still need to find out. Curr Med Res Opin. 2015;31:1855-60.
4. Coe DP. Exercise prescription in special populations: women, pregnancy, children and older adults. In: Swain DP, editor. ACSM's resource manual for exercise testing and prescription. 7th ed. China: Wolters Kluver Health-Lippincott Wiliams & Wilkins; p. 569.
5. Cygankiewicz I, Zareba W. Heart rate variability. Handb Clin Neurol. 2013;117:379-93.
6. D'Andrea A, Morello A, Iacono AM, et al. Right Ventricular Changes in Highly Trained Athletes: Between Physiology and Pathophysiology. J Cardiovasc Echogr. 2015;25:97-102.
7. Doyen B, Matelot D, Carré F. Asymptomatic bradycardia amongst endurance athletes. Phys Sportsmed. 2019;47.249-52.
8. Felber Dietrich D, Ackermann-Liebrich U, Schindler C, et al. Effect of physical activity on heart rate variability in normal weight, overweight and obese subjects: results from the SAPALDIA study. Eur J Appl Physiol. 2008;104.557–65.
9. Fox KR. Department of Health. Start active, stay active: report on physical activity in the UK: a report on physical activity from the four home countried Chief Medical Officers. London, 2011.
10. Henje Blom E, Olsson EM, Serlachius E, et al. Heart rate variability is related to self-reported physical activity in a healthy adolescent population. Eur J Appl Physiol. 2009;106.877–83.
11. Islam SKMA, Kim D, Lee YS, et al. Association between diabetic peripheral neuropathy and heart rate variability in subjects with type 2 diabetes. Diabetes Res Clin Pract. 2018;140:18-26.
12. Izci F, Hocagil H, Izci S, et al. P-wave and QT dispersion in patients with conversion disorder. Ther Clin Risk Manag. 2015;20:875-80.
13. Kaikkonen KM, Korpelainen RI, Tulppo MP, et al. Physical activity and aerobic fitness are positively associated with heart rate variability in obese adults. J Phys Act Health. 2014;11.1614–21.
14. Kuryanova EV, Tryasuchev AV, Stupin VO, et al. Effect of stimulation of neurotransmitter systems on heart rate variability and β-adrenergic responsiveness of erythrocytes in outbred rats. Bull Exp Biol Med. 2017;163.31-6.
15. Kuryanova EV, Tryasuchev AV, Stupin VO, et al. Effect of atropine on adrenergic responsiveness of erythrocyte and heart rhythm variability in outbred rats with stimulation of the central neurotransmitter systems. Bull Exp Biol Med. 2018;165:597-601.
16. Lammers AE, Munnery E, Hislop AA, et al. Heart rate variability predicts outcome in children with pulmonary arterial hypertension. Int J Cardiol. 2010;142:159-65.
17. Larosa C, Infusino F, Sciaglia GA, et al. Effect of primary percutaneous coronary intervention versus thrombolysis on ventricular arrhythmias and heart rate variability in acute myocardial infarction. Ital Heart J. 2005;6:629-33.
18. Lavie CJ, Church TS, Milani RV, et al. Impact of physicalactivity, cardiorespiratory fitness, and exercise training on markers of inflammation. J Cardiopulm Rehabil Prev. 2011;31:137–45.
19. Lazar JM, Khanna N, Chesler R, et al. Swimming and the heart. Int J Cardiol. 2013;168:19–26.
20. Lin YY, Lu WA, Hsieh YC, et al. Effect of position on the residual heart rate variability in patients after orthotopic heart transplantation. J Chin Med Assoc. 2017;80:63-71.
21. Lucini D, de Giacomi G, Tosi F, et al. Altered cardiovascular autonomic regulation in overweight children engaged in regular physical activity. Heart. 2013,99:376–81.
22. Madan K, Garg P, Deepak KK, et al. Heart rate variability in patients undergoing univentricular heart repair. Asian Cardiovasc Thorac Ann, 2014;22:402-8.
23. Maged AM, Abbassy AH, Sakr HRS, et al. Effect of swimming exercise on premenstrual syndrome. Arch Gynecol Obstet. 2018;297:951-9.
24. Martinez V, la Garza MS, Grazioli G, et al. Cardiac performance after an endurance open water swimming race. Eur J Appl Physiol. 2019;119:961-70.
25. Medeiros A, Oliveira EM, Gianolla R, et al. Swimming training increases cardiac vagal activity and induces cardiac hypertrophy in rats. Braz J Med Biol Res. 2004;37:1909–17.
26. Moraes IAP, Silva TD, Massetti T, et al. Fractal correlations and linear analyses of heart rate variability in healthy young people with different levels of physical activity. Cardiol Young. 2019;29:1236-42.
27. Nagai N, Moritani T. Effect of physical activity on autonomic nervous system function in lean and obese children. Int J Obes Relat Metab Disord. 2004;28:27–33.
28. Nagueh SF, Smiseth OA, Appleton CP, et al. Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. Eur Heart J Cardiovasc Imaging. 2016;17:1321-60.
29. Ozyilmaz I, Ergul Y, Tola HT, et al. Heart rate variability improvement in children using transcatheter atral septal defect closure. Anatol J Cardiol. 2016;16:290-5.
30. Rodel E, Pecanha T, Silva LPD, et al. Different times of day do not change heart rate variability recovery after light exercise in sedentary subjects: 24 hours Holter monitoring. Chronobiol Int. 2017;34:1354-65.
31. Nualnim N, Parkhurst K, Dhindsa,M, et al. Effects of swimming training on blood pressure and vascular function in adults >50 years of age. Am J Cardiol. 2012;109:1005–10.
32. Plews DJ, Laursen PB, Stanley J, et al. Training adaptation and heart rate variability in elite endurance athletes: opening the doorto effective monitoring. Sports Med. 2013;43:773–81.
33. Sandercock GRH, Bromley PD, Brodie DA. Effects of exercise on heart rate variability: inferences from meta-analysis. Med Sci Sports Exerc. 2005;37:433–9.
34. Shaffer F, Ginsberg JP. An overview of heart rate variability metrics and norms. Front Public Health. 2017;5:258.
35. Sharma VK, Subramanian SK, Arunachalam V, et al. Heart rate variability in adolescents—normative data stratified by sex and physical activity. J Clin Diagn Res. 2015;9:08–13.
36. Sen J, McGill D. Fractal analysis of heart rate variability as a predictor of mortality: A systematic review and meta-analysis. Chaos. 2018;28:072101.
37. Sharma VK, Subramanian SK, Radhakrishnan K, et al Comparison of structured and unstructured physical activity training on predicted vo2max and heart rate variability in adolescents - A Randomized Control Trial. J Basic Clin Physiol Pharmacol. 2017;28:225-38.
38. Sessa F, Anna V, Messina G, et al. Heart rate variability as predictive factor for sudden cardiac death. Aging (Albany NY). 2018;10:166-77.
39. Shoemaker LN, Wilson LC, Lucas SJE, et al. Swimming-related effects on cerebrovascular and cognitive function. Physiol Rep. 2019;7,e14247.
40. Tanaka, H. Swimming exercise: impact of aquatic exercise on cardiovascular health. Sports Med. 2009;39:377–87.
41. Tian J, Yu T, Xu Y, et al. Swimming training reduces neuroma pain by regulating neurotrophins. Med Sci Sports Exerc. 2018;50:54-61.
42. World Health Organization. Global strategy on diet, physical activity and health. Information sheet: global recommendations on physical activity for health 5–17 years old.2011.
43. Xhyheri B, Manfrini O, Mazzolini M, et al. Heart rate variability today. Prog Cardiovasc Dis. 2012;55:321-31.