Lifetime Exposure to Recreational Swimming Training and its Effects on Autonomic Responses

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Abstract

The aim of the present investigation was to assess the effect of long-term recreational swimming training on the cardiac autonomic responses in the healthy population. 70 habitual recreational swimmers (48.6±14.3 yrs.) and 60 sedentary adults (51.5±10.4 yrs.) were recruited. Arterial blood pressure was recorded with participants in supine position for 10 minutes, and the last 5 minutes were used to assess heart rate variability, baroreflex sensitivity, and hemodynamic analysis. The analysis of the questionnaire showed that the swimmers had practiced swimming for a mean of 14 years and 207 minutes/week. No difference was detected for body mass index between groups. Heart rate variability showed significant differences between groups both in the time and frequency domain analysis. We also found significant differences for baroreflex sensitivity. At rest, cardiac output and stroke volume were higher, whereas, heart rate, mean arterial pressure and total peripheral resistances were lower in the swimmers than in the sedentary subjects. Since heart rate variability measures are independent predictors of mortality, the present findings suggest that habitual recreational swimming may be protective against sudden cardiovascular events and, more in general, have a positive impact on cardiovascular health.

Keywords: exercise; baroreflex sensitivity; heart rate variability; hemodynamic.

Running head: Physical activity and autonomic nervous system

Introduction

Being inactive increases the risk of developing a variety of diseases, including diabetes, hypertension, overweight, osteoporosis, and depression [1]. Additionally, sedentariness has been associated with higher all-cause and cardiovascular mortality, and cardiovascular disease (CVD) is the first leading cause of mortality in industrialized countries [1]. Conversely, physical exercise is associated with hemodynamics changes, increasing volume load at the heart level during endurance training, in contrast to pressure load during strength exercise. These differences in loading will cause different cardiovascular responses to exercise, changes that are well described as “athlete’s heart” [2]. Exercise training conducted for long term influences cardiac rhythmic, inducing sinus bradycardia during resting condition. The cardiovascular system is generally controlled by autonomic regulation through the activity of sympathetic and parasympathetic pathways of the autonomic nervous system (ANS). It is widely presumed that regular endurance program induces adaptations in the ANS that result in both changes in several cardiovascular variables at rest and in alterations in the reflex control of the circulation [3]. Analysis of heart rate variability (HRV) and baroreflex sensitivity (BRS) enable understanding of this control mechanism. The ANS regulates heart rate during physical activity. The ANS is composed of a parasympathetic and a sympathetic branch that operate in a reciprocal and inverse manner: a decrease in heart rate variability is caused by an increase in sympathetic activity combined with decreased parasympathetic drive, whereas an increase in HRV is characterized by parasympathetic reactivation and sympathetic withdrawal. HRV can be evaluated by time and frequency domain indices, reflecting the activity of the autonomic nervous system. Among the most used indices, the standard deviation of normal beat-to-beat intervals (SDNN), the root-mean-square of successive R–R (RMSSD) and high frequency (HF) power has been suggested to reflect indexes of cardiac vagal outflow [4]. Instead, low frequency (LF) power is mediated by both cardiac vagal and sympathetic nerves [5].

Physical activity and exercise are highly suitable for health promotion as well as prevention and treatment of risk factors for cardiovascular disease [6]. However, the optimal dose remains unclear [7]. Constant practice of physical exercise is associated with a lower risk of cardiovascular events, and elite athletes live longer than the general population [8]. It can be hypothesized that physical exercise would be effective in improving the autonomic balance in the general population while also developing physical fitness. On this point, there is a debate about the dose-response relationship of exercise necessary to influence the autonomic nervous system responses in order to be an effective means to positively modify factors that are associated with increased incidence of cardiac events. Until now, several longitudinal studies have been conducted on the effect of exercise training on HRV in non-athletes, although no consistent changes have been observed both in HRV parameters and BRS [9]. The authors blamed the short duration of the training program, suggesting that to obtain some effect on ANS parameters, the training program should last at least for a period of one year. Many features disturb the physiological significance of these studies. Two of them are the age and sex, which contributes to the discrepant findings in the literature. HRV decreases with age and changes as a function of sex, so that studies should take into consideration a sample size of both sexes with a wide range in terms of age. Loimaala et al. [10] investigated the effect of training on 26 sedentary subjects with age from 35 to 55 years old, with a training program of 5 months. They found no significant change of HRV time and frequency domain parameters or BRS in either of the exercise groups. An exercise-training program of only 5 months was not able to modify the cardiac vagal outflow in sedentary, middle-aged persons.

Duration and intensity of training are the most important factors that could affect cardiac autonomic function. When researchers investigate the effect of exercise on HRV or BRS in a group of athletes with respect to the sedentary population, they found, in most of the cases, significant differences. The majority of studies that have compared HRV between well-trained and sedentary subjects have revealed that athletes have significantly higher HRV indexes than inactive subjects, even though contradictory findings have also been conveyed [9]. In all these studies, measures of HRV have been compared between high-level young athletes and sedentary, age-matched counterparts, but the results do not provide information as to whether the cardiac autonomic function can be enhanced by exercise training in the middle-aged sedentary population. A limitation of these studies is the relatively short duration of the training program, lasting no more than five months [10].

The world health organization (WHO) guidelines for physical activity recommend, for adults aged 18–64 years, at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or to do at least 75 minutes of vigorous-intensity aerobic activity throughout the week, or an equivalent combination of moderate- and vigorous-intensity activity [1]. Moreover, they recommend that, for health benefits, adults should increase their moderate-intensity aerobic physical activity to 300 minutes per week, or engage in 150 minutes of vigorous-intensity aerobic physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activity [1]. Despite recreational swimming is quite widespread in the general population as an habitual mode of exercise, little is known on whether and how habitual swimming training affects the cardiac autonomic response and, more in general, the cardiovascular health. Moreover, swimming has been widely promoted and prescribed without the underpinning of firm scientific support from clinical studies [6]. Therefore, the aim of our study was to investigate the effects of long-term swimming on the cardiac autonomic response, baroreflex sensitivity, and hemodynamic activity in the healthy population. The increased cardiac vagal activity associated with swimming training could be of clinical significance, since both are related to increased life expectancy and prevention of cardiovascular events.

Methods

Subjects

The study sample consisted of 70 habitual recreational swimmers (48.6±14.3 yrs.; 52 males, 18 females) and 60 sedentary healthy adults (51.5±10.4 yrs.; 23 males, 37 females). Swimmers were recruited from three different swimming pools of the same city. Inclusion criteria were having practiced swimming for at least 1 year, having an age greater than 30 years, and no particular cardiovascular pathologies that may affect physical exercise. On the other hand, for the control group, we recruited healthy people who have not practiced any specific physical exercise in the last year of their life, and an age greater than 30 years old.

The participants were asked to avoid smoking and drinking alcoholic or caffeinated beverage before the experimental procedures, and none of them was under medication. This study was approved by Bioethics Committee of our University, and all participants were informed of the benefits and risks of the investigation prior to signing an institutionally approved informed consent document to participate in the study [11].

Procedures

The participants compiled a questionnaire with different questions on their anthropometric, demographic, habits, training, and health data. Thereafter, we recorded blood pressure with participants placed in a supine position for 10 min in a quiet room with stable temperature (22°C; 52% of humidity), without speaking or making any movements, and with a respiratory frequency maintained at 12-15 breaths/min following the rhythm of a metronome (0.20-0.25 Hz). Participants wore a finger plethysmography for non-invasive continuous blood pressure monitoring (100 Hz, Portapres device Mod. 2, The Netherlands), necessary to extract time series of beat-to-beat intervals and systolic as well as diastolic pressures. Time series were filtered to exclude artefacts and analyzed with Kubios HRV software (v. 2.0, 2008, University of Kuopio, Finland).

Measurements

Time domain HRV indices investigated were the square root of the mean squared differences of successive R-R intervals (RMSSD), and the standard deviation of normal to normal R-R intervals (SDNN). Spectral analysis provides two main frequency components: low frequency (LF) ranging from 0.04 to 0.15 Hz, and high frequency (HF) centered at the breathing frequency (0.15-0.4 Hz). It has been shown that HF is an index of vagal tone, whereas both sympathetic and vagal activities contribute to the LF of HRV [4]. In order to provide an index of sympathetic and vagal modulation, we expressed both LF and HF in normalized units [4]. Such normalized units are obtained by dividing the power of each component by total variance from which the very-low-frequency component had been subtracted and multiplying this value by 100 [HF/(total power – VLF) x 100], the same for LF. Although they have a mixed origin, the low and high frequency components measured in normalized units provide quantitative markers of cardiac sympathetic and vagal modulation, respectively [12, 13].

Baroreflex sensitivity was evaluated using Beatscope version 1.1a (TNO/BMI, The Netherlands), with a BRS add-on module based on cross-correlation analysis. This method is based on time domain of spontaneously occurring sequences of 4 or more consecutive beats characterized by either a progressive rise in systolic blood pressure (SBP) and R-R interval (+R-R /+SBP sequences) or by a progressive decrease in both measures (-R-R/-SBP sequences). The slope of the regression line between SBP and R-R interval changes is taken as an index of BRS modulation of heart rate (HR), same as the laboratory method based on injection of vasoactive drugs [14].

The pulse contour method of Wesseling (Modelflow method) was used to evaluate stroke volume (SV), cardiac output (CO), and total peripheral vascular resistance (TPR) from the blood pressure waveform [15].

Statistical Analysis

For the analysis of autonomic function, the last 5 min of recordings was used for calculations, as recommended by guidelines for HRV analysis during short-term recording [4].

The normal distribution of data was verified with Shapiro-Wilk test. Paired sample t-tests were used to verify, for each parameter, the differences between groups. Effect size (ES) estimates were calculated by subtracting the means and dividing the result by the pooled standard deviation. Effect size values of <0.20, >0.20–0.50, >0.50–0.80, >0.80 were considered to represent trivial, small, medium and large differences, respectively [16]. Mean differences and 95% confidence interval are also presented. The data were analyzed with SPSS v22.0 (SPSS, Chicago, USA).

Results

Lifetime and current sport experience

The total study sample consisted of 130 participants, divided in 70 swimmers and 60 sedentary subjects. Table 1 displays the population characteristics, with differences and effect size between groups. The analysis showed a significant difference between groups for weight, height, number of cigarettes smoked in a day, and we found differences on how they perceived physical fitness, answering with "I am in a good shape" by 73% of swimming group with respect to 57% of sedentary participants. On average, the swimmers trained 3 times per week of 1 hour each, and they had been swimming without interruption for 14 years. Most of them (71%) practiced unsupervised swimming and 86% of them did sport since they were young. The control group was sedentary for an average 13 years, with a high variability (standard deviation:17 years).

***** Table 1 near here *****

Cardiac autonomic control indexes

We found a significant difference between groups for blood pressure (mean arterial pressure, $t(128)=-3.86$, $p<0.001$, $d=0.68$ (medium), mean diff.= -11.25, 95% CI [-17.02, -5.49]) and heart rate ($t(128)=-5.16$, $p<0.001$, $d=0.91$ (large), mean diff.= -10.14, 95% CI [-14.04, -6.25]) (Table 1). Conversely, we did not find significant difference between groups for BMI ($t(128)=-0.86$, $p=0.39$, mean diff.= -0.51, 95% CI [-1.68, 0.66]).

In the time domain analysis of HRV, significant differences between groups were detected for SDNN ($t(128)=2.14$, $p=0.034$, $d=0.38$ (small), mean diff.= 6.18, 95% CI [0.47, 11.89]) and RMSSD ($t(128)=3.47$, $p<0.001$, $d=0.62$ (medium), mean diff.= 11.66, 95% CI [5.01, 18.31]) (Figure 1A). In the frequency domain analysis, swimmers had higher HF ($t(128)=2.65$, $p=0.009$, $d=0.47$ (small), mean diff.= 8.36, 95% CI [2.12, 14.59]) and lower LF power (t(128)=-2.65, *p*=0.009, *d*=-0.47 (small), mean diff.= -8.37, 95% CI [-14.62, -2.13]) than sedentary subjects (Figure 1B).

***** Figure 1 near here *****

Swimmers showed higher cardiac output (t(128)=2.88, *p*=0.005, *d*=0.51 (medium), mean diff.= 0.71, 95% CI [0.22, 1.19]) and stroke volume (t(128)=5.08, *p*<0.001, *d*=0.90 (large), mean diff.= 20.61, 95% CI [12.58, 28.63]), meanwhile total peripheral resistances was lower (t(128)=-3.16, *p*=0.002, *d*=-0.55 (medium), mean diff.= -0.37, 95% CI [-0.60, -0.14]) with respect to the sedentary group. We also found significant differences between the trained and sedentary subjects on BRS (t(128)=2.01, *p*=0.046, *d*=0.35 (small), mean diff.= 3.34, 95% CI [0.06, 6.63]) (Figure 2).

***** Figure 2 near here *****

Discussion

The results of this investigation suggest that the constant practice of recreational swimming for long time, 14 years on average in our subjects, have a strong effect on cardiac autonomic function evaluated by HRV and BRS. Indexes of cardiac vagal outflow, that is SDNN, RMSSD, and HF power, were clearly different in swimmers as compared to sedentary counterparts. Furthermore, differences were observed in BRS, which is a measure of reflex cardiac vagal responsiveness [17–20]. Loimaala et al., [10] suggest that, to obtain a clinically significant increase in HRV and BRS, exercise training should be practiced consistently for many years. For this reason, in this investigation, we have assessed swimmers exercising for long time to determine if that type of exercise elicited a change in the cardiac autonomic control in the healthy population.

In a recent study, Bessem et al. [2] showed that > 3 hours/week is the best minimum (current) level of exercise exposure to induce a significant increase in training-related ECG changes. Moreover, when a subject is exposed to over 3000 exercise hours (lifetime), the prevalence of training related ECG changes significantly increased compared to an exposure of <3000 hours. A limitation of that study was that, as in our study, data were collected retrospectively through a questionnaire. It is indeed very difficult to collect a big cohort of lifetime exposure to exercise in any other way. According to the current literature, the autonomic cardiovascular adaptations with aerobic endurance exercise training are associated with decreased cardiovascular risk factors, and reduced risk factors are associated with elevated autonomic vagal activity [21].

Previous studies have demonstrated that the practice of swimming decreased systolic blood pressure in adults >50 years of age. These decreases are obtained within a relatively short period, using a frequency and intensity of exercise that most healthy older adults are able to perform [22]. In addition, the hypotensive effects of swimming are accompanied by significant improvements in arterial compliance, endothelium-dependent vasodilation, and cardiovagal BRS, important factors of vascular functions that are closely related with the pathogenesis of cardiovascular diseases [23]. However, research on the effects of swimming on cardiovascular health profile is extremely limited, and in the most of cases are controversial [6]. We can hypothesize that these different cardiac autonomic responses after swimming training could be related to this training mode, which differs from other aerobic activity (i.e. running training) due to the body position in the water, breathing pattern, temperature regulation, the water (hydrostatic) pressure, which leads to a decrease in systemic vascular resistance [24–27]. To our knowledge, our study is the first showing the beneficial role of swimming in modulating cardiac autonomic control by improving HRV, BRS, and hemodynamic variables. Prospective longitudinal cohort studies have shown that impaired cardiac autonomic control is a strong predictor of all-cause and cardiovascular disease mortality [28] and can be identified by evaluating indices of heart rate variability, baroreflex sensitivity, and hemodynamic parameters.

Maintenance of positive mental health and the prevention of mental disorders through regular physical activity has been a focus of considerable research [21]. It has been widely documented that aerobic exercise significantly alleviates the depressive state and reduces the level of cortisol and epinephrine excretions, as well as improving physiological fitness conditions. Regular physical exercise can promote a variety of psychological and physiological conditions and may be beneficial in the primary care of adolescent with depressive symptoms [29]. In our investigation, we found differences on subjective feeling as the 73% of swimming group answered “I am in a good shape” with respect to 57% of sedentary participants [30]. The effect of physical activity on depressive symptoms and anxiety is well-established, although dose–response issues still need experimental research with a prevention-based focus. Moderate to vigorous physical activity was associated with better self-reported health-related quality of life in healthy adults [7]. Much of the general population accepts the importance of being physically active for health and well-being. Moreover, it is widely believed that participation in sport and physical activity during youth can be a significant factor in lifelong engagement therein [31]. In fact, most of our participants (86%) have been practiced sport since they were young (see Table 1). It is widely believed that active participation in sports during youth is an important prerequisite for adult involvement in physical activity. For this reason, school physical education is, in turn, often showed as a potential intermediary for enhancing young people's engagement with physically active recreation in their leisure and, in the longer run, over the lifetime [32].

Furthermore, sedentary adolescents have altered body size/composition, and this has also been associated with subsequent adult health outcomes. In general, unfit subjects within a fatness category (low or high BMI) had a higher cardiovascular disease risk profile than their fit counterparts. In our investigation, we did not find significant differences between groups for BMI. This means that normal BMI with low-level of cardiovascular fitness has higher probability to develop cardiovascular disease as unfit subjects with high BMI. In a recent follow-up study, Cornwell et al., [33] found that the risk of heart failure in elderly was significantly lower among overweight fit and obese-fit compared with lean and low fit individuals. Taken together, these findings suggest that higher levels of cardiorespiratory fitness and physical activity are inversely associated with long-term risk of heart failure across all BMI categories.

Conclusions

In conclusion, this retrospective investigation provides convincing evidence of the significant protective role of moderate-physical activity against the risk of premature mortality, cardiovascular disease, stroke, hypertension. In many instances, the dose-response relationship is linear with further health benefits with increasing levels of activity. As a practical recommendation, we would suggest the use of ≥ 200 minutes/week practicing swimming as a minimum value. We also showed that a lifetime exposure of >1 year of swimming is necessary to elicit cardiac autonomic response, changes in the baroreflex sensitivity, and hemodynamic activity in healthy population.

Bibliography

[1] Global Recommendations on Physical Activity for Health., World Health Organization; 2010, p. 10–10.

[2] Bessem B, De Bruijn MC, Nieuwland W, Zwerver J, Van Den Berg M. The electrocardiographic manifestations of athlete’s heart and their association with exercise exposure. Eur J Sport Sci 2018;18:587–93.

[3] Seals DR, Chase PB. Influence of physical training on heart rate variability and baroreflex circulatory control. J Appl Physiol 1989;66:1886–95.

[4] Camm AJ, Malik M, Bigger JT, Günter B. Task force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Heart rate variability: standards of measurement, physiological interpretation and clinical use. Circulation 1996;93:1043–65.

[5] Perini R, Veicsteinas A. Heart rate variability and autonomic activity at rest and during exercise in various physiological conditions. Eur J Appl Physiol 2003;90:317–25.

[6] Tanaka H. Swimming exercise: Impact of aquatic exercise on cardiovascular health. Sport Med 2009;39:377–87.

[7] Warburton DER, Katzmarzyk PT, Rhodes RE, Shephard RJ. Evidence-informed physical activity guidelines for Canadian adults. Appl Physiol Nutr Metab 2007;32.

[8] Lucia A. Elite athletes live longer than the general population: a meta-analysis. Mayo Clin Proc 2014;89:1195–200.

[9] Aubert AE, Seps B, Beckers F. Heart Rate Variability in Athletes. Sport Med 2003;33:889–919.

[10] Loimaala A, Huikuri H, Oja P, Pasanen M, Vuori I. Controlled 5-mo aerobic training improves heart rate but not heart rate variability or baroreflex sensitivity. J Appl Physiol 2000;89:1825–9.

[11] Harriss DJ, Macsween A, Atkinson G. Ethical Standards in Sport and Exercise Science Research: 2020 Update. Int J Sports Med 2019;40:813–7.

[12] Malliani A, Pagani M, Lombardi F, Cerutti S. Cardiovascular neural regulation explored in the frequency domain. Circulation 1991;84:482–92.

[13] Pagani M, Lombardi F, Guzzetti S, Rimoldi O, Furlan R, Pizzinelli P, et al. Power spectral analysis of heart rate and arterial pressure variabilities as a marker of sympatho-vagal interaction in man and conscious dog. Circ Res 1986;59:178–93.

[14] Parati G, Di Rienzo M, Mancia G. How to measure baroreflex sensitivity: from the cardiovascular laboratory to daily life. J Hypertens 2000;18:7–19.

[15] Bos WJ, van Goudoever J, van Montfrans GA, van den Meiracker AH, Wesseling KH. Reconstruction of brachial artery pressure from noninvasive finger pressure measurements. Circulation 1996;94:1870–5.

[16] Cohen J. Statistical power analysis for the behavioral sciences, (2nd ed.). Hillsdale, NJ : Lawrence Erlbaum. Hillsdale, NJ 1988:20–6.

[17] Piras A, Persiani M, Damiani N, Perazzolo M, Raffi M. Peripheral heart action (PHA) training as a valid substitute to high intensity interval training to improve resting cardiovascular changes and autonomic adaptation. Eur J Appl Physiol

2015;115:763–73.

[18] Piras A, Gatta G. Evaluation of the Effectiveness of Compression Garments on Autonomic Nervous System Recovery After Exercise. J Strength Cond Res 2017;31:1636–43.

[19] Piras A, Cortesi M, Campa F, Perazzolo M, Gatta G. Recovery Time Profiling After Short-, Middle- and Long-Distance Swimming Performance. J Strength Cond Res 2019;33:1408–15.

[20] Piras A, Campa F, Toselli S, Di Michele R, Raffi M. Physiological responses to partial-body cryotherapy performed during a concurrent strength and endurance session. Appl Physiol Nutr Metab 2019;44:59–65.

[21] Toni G, Belvederi Murri M, Piepoli M, Zanetidou S, Cabassi A, Squatrito S, et al. Physical Exercise for Late-Life Depression: Effects on Heart Rate Variability. Am J Geriatr Psychiatry 2016;24:989–97.

[22] Nualnim N, Parkhurst K, Dhindsa M, Tarumi T, Vavrek J, Tanaka H. Effects of swimming training on blood pressure and vascular function in adults >50 years of age. Am J Cardiol 2012;109:1005–10.

[23] Yuan WX, Liu H Bin, Gao FS, Wang YX, Qin KR. Effects of 8-week swimming training on carotid arterial stiffness and hemodynamics in young overweight adults. Biomed Eng Online 2016;15.

[24] Koenig J, Jarczok MN, Wasner M, Hillecke TK, Thayer JF. Heart Rate Variability and Swimming. Sport Med 2014;44:1377–91.

[25] Medeiros A, Oliveira EM, Gianolla R, Casarini DE, Negrão CE, Brum PC. Swimming training increases cardiac vagal activity and induces cardiac

hypertrophy in rats. Brazilian J Med Biol Res 2004;37:1909–17.

[26] Lazar JM, Khanna N, Chesler R, Salciccioli L. Swimming and the heart. Int J Cardiol 2013;168:19–26.

[27] Piras A, Raffi M, Atmatzidis C, Merni F, Di Michele R. The Energy Cost of Running with the Ball in Soccer. Int J Sports Med 2017;38:877–82.

[28] Goldberger JJ, Arora R, Buckley U, Shivkumar K. Autonomic Nervous System Dysfunction: JACC Focus Seminar. J Am Coll Cardiol 2019;73:1189–206.

[29] Nabkasorn C, Miyai N, Sootmongkol A, Junprasert S, Yamamoto H, Arita M, et al. Effects of physical exercise on depression, neuroendocrine stress hormones and physiological fitness in adolescent females with depressive symptoms. Eur J Public Health 2006;16:179–84.

[30] Stoll O, Alfermann D. Effects of physical exercise on resources evaluation, body self-concept and well-being among older adults. Anxiety, Stress Coping 2002;15:311–9.

[31] Laakso L, Telama R, Nupponen H, Rimpelä A, Pere L. Trends in leisure time physical activity among young people in Finland, 1977-2007. Eur Phys Educ Rev 2008;14:139–55.

[32] Green K. Mission impossible? Reflecting upon the relationship between physical education, youth sport and lifelong participation. Sport Educ Soc 2014;19:357–75.

[33] Cornwell WK, Neeland I, Pandey A, Willis B, Leonard D. Combined Association of Midlife Obesity and Fitness With Longterm Risk of Heart Failure-The Cooper Center Longitudinal Study. Circulation 2013;128.

Figure and table legends

Figure 1. Histograms represent mean (±SD) of the time (A) and frequency (B) domain of HRV parameters between swimming (black) and control (grey) group.

Abbreviations: SDNN - standard deviation of normal to normal R-R intervals; RMSSD - square root of the mean squared differences of successive R-R intervals; HF – high frequency; LF – low frequency. Asterisks represent significant differences ($p<0.05$).

Figure 2. Histograms show the mean (±SD) of hemodynamic variables between swimming (black) and control (grey) group. Asterisks represent significant differences ($p<0.05$).

Table 1. Population characteristics. Data are showed as mean ± standard deviation and number with percentage value between brackets. Bolded text denotes a significant main effect ($p<0.05$) with effect size values (Cohen's d).