NON-INVASIVE INVESTIGATION ON HEART RATE VARIABILITY AND ENERGY EXPENDITURE DURING COMPETITION AND PHYSICAL ACTIVITY OF CHESS PLAYERS

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Abstract

A chess game represents a legitimate psychophysiological stress and it is a challenging and high cognitive demand task that requires full attention and energy over the course of the game. In order to monitor performance of chess players, one of the most popular psychophysiological markers is the heart rate variability (HRV) to date (Fuentes et al., 2018). Alongside with the HRV parameters, heart rate (HR) can also be used as a non-invasive measure of calorie expenditure for chess players to monitor their performance. Therefore, the aim of present study was to compare the HRV and calorie expenditure of chess players before-during-after the chess competition and running exercises.

The sample group consists of 10 volunteer men and women between the ages of 15-40 who have been playing chess regularly for at least 5 years. According to the physical activity readiness survey (FAHOA), healthy chess players were included in the current research. The participants' chess competition and running exercises took place in 3 different time periods; HRV and HR values were taken before (15 min), during (30 min) and after (15 min). HRV, HR and body composition were obtained from the participants. According to the results of the present study, There was a significant difference between HRV [RR *(ms)*] before (742.5 ± 115.3), during (730.8 ± 151.1) and after (794.5 ± 126.8). In addition to this, there was a significant difference was found between the calorie expenditure (138.1 ± 65.8 kcal) during the chess game and the calories (260.5 ± 109 kcal) spent during the running exercise. Results show that running exercise causes more energy consumption than chess competition. In conclusion, psychophysiological measurements have an impact on the monitoring chess players' performance.

Key words: *Physical Activity, Mental Activity, Autonomic Nervous System, Parasympathetic Activity*

Introduction

Chess game is one of the very old intelligence games. Chess has long been a model system for studying complex thought processes (Sigman, et al., 2010). This game contributes many issues in a positive way such as problem solving, analytical thinking, fast and accurate thinking. It is well known to be a purely mental game (Reti, 2000). However, chess players face intense visual and mental burden during and before the competition. Many psycho-social stressors are accompanied by visual and mental loading. Stressors can cause a decrease in high frequency oscillations reflecting the effect of parasympathetic nervous system on heart rate variability (HRV) (Tok, et al., 2018). This game that covers mental processes has a significant impact on parameters such as heart rate (HR), HRV, and calorie expenditure where players compete over time (Fuentes-García, et al., 2019).

In particular, heart rate variability (HRV) has become a widely used tool by researchers to study the autonomous control of the heart (Serrador, et al., 1999). HRV is an indicator that reveals the interaction between the brain and the heart. HRV can be used to evaluate the autonomic functions of the heart (Kaikkonen, et al., 2008). Accordingly, the Autonomic Nervous System (OSS) has a regulatory effect on heart work and provides information about the evaluation of OSS, cardiac sympathetic and vagal balance (Chen, et al., 2011). On one hand, parasympathetic activity, physical and mental activities can become dominant in resting time, on the other hand sympathetic activity can be more effortful in stressful situation (Aras, et al., 2014). In sport science related HRV literature different methods have been used for analyzing HRV parameters. For example, these are time-domain, frequency-domain and nonlinear measurements (Shaffer, & Ginsberg, 2017). In recent years, there is a growing body of research related with HRV in sports science, physical activity and motor control studies (Gorgulu, Cooke, & Woodman, 2019).

Therefore, the aim of the current study was to compare the relationship between chess players' HRV and calories expenditure before-during-after the chess competition and basic running exercises.

Methods

Participants: A total of ten male (n = 8) and female (n = 2) chess players (age 28 ± 8.1 years; weight 74.5 ± 18.3 kg; height 176.3 ± 7.6 cm; bmi 22.5 ± 7.1 kg / m^2; bmr 1826 ± 371 kcal; tbf 16.4 ± 7.6%; fm 12.8 ± 8.2 kg; ffm 58.7 ± 12.8 kg and tbw 45.2 ± 9.5 kg) constituted the sample group of the study. According to the physical activity readiness questionnaire (FAHOA), healthy ones were included in the study. Patients with any disorders in the cardiovascular, digestive and respiratory systems, those who use addictive substances such as cigarettes, alcohol, and those who use drugs that affect mental and physical performance before the competition were not included in the study. This research was carried out in accordance with the Helsinki Declaration of human rights. The study was carried out in accordance with the decision of Bursa Uludağ University Ethics Committee dated 16 December 2019 and numbered (2019-20 / 15).

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Experimental Design: In this study, HRV measurements and calorie expense were determined in 3 different time periods (15 minutes before the competition, 30 minutes and 15 minutes after the competition) during the chess competition and running exercise. Before the chess competition, each participant was given a personal information form, and each participant wore a chest strap Polar H7 device. Participants of the study were determined by TANITA device, height, weight and body composition. After giving information about the applications to be made to the participants, a chess match was held on the 1st day. The chess clock (Schach Queen E410) was used as time in competitions. Each player was given 15 minutes per person and HRV recordings were analyzed. If the chess game ends before 30 minutes, a chess match was held again without a break. 15 minutes passive rest before the competition, 30 minutes after the chess match and 15 minutes passive rest again, the records were taken. The other application of the study was done on the 2nd day after 24 hours of physical activity. A participant FAHOA questionnaire was made before physical activity. According to FAHOA, the athletes that were eligible were put into practice after being selected. In the physical activity, participants were given a passive rest for 15 minutes and then walking and running on the treadmill for 30 minutes (6 km/h speed).

Measurements

Body Composition: The lengths of the participants who participated in the study were measured using the Mesitaş height meter (Germany) device. Body composition was analyzed with TANITA BC-418MA (Japan) Segmental Body Analysis Monitor. The device was analyzed for total body weight, BMI, basal metabolic rate, BMH (kj and kcal), impedance (ohms), fat rate (%), fat amount (kg), lean mass (kg) and total body fluid (kg).

HRV: It is a parameter that reflects the harmony of the signals between the brain and heart. In the study, HRV was measured with Polar H7 (Polar Electro, Kempele, Finland) device. Mental and physical activity HRV values were analyzed with these chest-worn devices.

Physical readiness questionnaire: A test was applied to understand that the participants in the research were physically healthy. This test consists of 7 questions and will allow athletes to participate in the research without any health check.

Statistical analyses: The data was analyzed with SPSS in Windows 23.0 (SPSS Inc, Chicago, USA) statistics program. Cohen's impact dimensions (d) were calculated to compare the magnitude of the difference between the groups. In two different experiments (chess competition and physical activity), the comparison of the differences in HRV and Energy expenditures was made with the Two-way ANOVA (variance analysis for repeated measurements) test. The level of significance was set at $p < 0.05$.

Results

The data obtained in this study were analysed with the chess competition, the time-consuming, frequency-taking and nonlinear measurement parameters of the running exercise, and the amount of energy spent. Information on the effect size is shown in Table 1.

According to results showed in Table 1, there was a significant difference on time domain measurements of HRV such as RR (ms) between chess competition and running exercises (p <0.001). A significant difference was found in the Calorie (p <0.001) variable in energy expenditure before, during and after chess and running training competitions.

Table 1. Heart rate variability parameters and energy expenditure values of chess competition and running exercise.

Variable		*Pre-test*	*Test*	*Post-test*	*F*	*η²*	*Cohen's d*
		Mean ± SD	*Mean ± SD*	*Mean ± SD*			
RR (ms)	*CE*	742.5 ± 115.3	730.8 ± 151.1	794.5 ± 126.8	23.57***	0.567	2.2886ƫƫƫ
	RE	808.3 ± 108.1	547.9 ± 108.6	775.8 ± 143.5			
SDNN (ms)	*CE*	54 ± 12.8	43 ± 14.1	56.9 ± 12.3	7.038**	0.281	1.2503ƫƫƫ
	RE	52.3 ± 11.8	19.2 ± 10.2	58.9 ± 12.3			
RMSSD (ms)	*CE*	38.6 ± 11.2	31.6 ± 13.9	39.8 ± 12.5	3.777	0.173	0.9147ƫƫƫ
	RE	37.2 ± 14.4	14.8 ± 10.5	46.3 ± 35.7			
NN50 (beats)	*CE*	152.4 ± 67.8	247.2 ± 214	194.1 ± 109.9	6.886**	0.277	1.2379ƫƫƫ
	RE	179.1 ± 119.6	42.3 ± 48.5	165.1 ± 128			
PNN50 (%)	*CE*	14.1 ± 8.3	11.2 ± 10.4	18.2 ± 11.6	3.058	0.145	0.8236ƫƫƫ
	RE	17.1 ± 12.4	1.4 ± 1.7	15.8 ± 13.7			
RR TRAINGULAR-INDEX	*CE*	13.6 ± 2.9	11.7 ± 4.9	14.6 ± 2.9	9.002***	0.333	1.4132ƫƫƫ
	RE	12.6 ± 2.7	4.6 ± 2.6	13.3 ± 4.2			
TINN (ms)	*CE*	293.4 ± 82.4	290.5 ± 58.8	301.5 ± 57.7	2.634	0.128	0.7663ƫƫƫ
	RE	290.5 ± 58.8	274.4 ± 86	328 ± 164.2			
VLF (log)	*CE*	5.2 ± 0.5	4.3 ± 0.9	5.2 ± 0.4	4.729*	0.208	1.0249ƫƫƫ
	RE	5.3 ± 0.7	3 ± 1.2	4.9 ± 0.6			
LF (log)	*CE*	7.4 ± 0.5	6.7 ± 1.1	7.6 ± 0.4	7.741**	0.301	1.3124ƫƫƫ
	RE	7.5 ± 0.4	5.1 ± 1.2	7.4 ± 0.8			
HF (log)	*CE*	6.1 ± 0.6	5.7 ± 1.4	6.3 ± 0.6	14.66***	0.449	1.8054ƫƫƫ
	RE	6.3 ± 0.6	3.5 ± 1.4	6.2 ± 1			
SD1 (ms)	*CE*	27.3 ± 7.9	22.3 ± 9.8	28.2 ± 8.8	4.290*	0.192	0.9749ƫƫƫ
	RE	28.2 ± 10.2	10.5 ± 7.4	32.7 ± 25.2			
SD2 (ms)	*CE*	71.4 ± 17.3	56.4 ± 18.3	75.2 ± 16	7.458**	0.293	1.2875ƫƫƫ
	RE	68.2 ± 14.3	25 ± 12.7	76.3 ± 33.9			
SD2/SD1	*CE*	2.7 ± 0.6	2.7 ± 0.8	2.7 ± 0.5	0.073	0.004	0.1267ƫ
	RE	2.5 ± 0.5	2.7 ± 0.6	2.7 ± 0.9			
PNS INDEX	*CE*	-0,9 ± 0.7	-0.8 ± 1.3	-0.7 ± 0.9	15.66***	0.465	1.8646ƫƫƫ
	RE	-0.6 ± 0.8	-2.6 ± 0.9	-0.6 ± 1.5			
SNS INDEX	*CE*	1 ± 1	1.3 ± 1.5	0.6 ± 1	2.878	0.138	0.8002ƫƫƫ
	RE	-4.5 ± 16.3	5.3 ± 3.2	0.8 ± 1.4			
EE (kcal)	*CE*	59.5 ± 25.1	138.1 ± 65.8	49.5 ± 23.8	15.194**	0.458	1.8385ƫƫƫ
	RE	44.8 ± 22.1	260.5 ± 109	54.7 ± 34.5			

Note: CE: Chess Exercise; RE: Running Exercise; pretest: 15 minutes before exercise; test: 30 minute During exercise; posttest: 15 minutes after exercise; RR: time between RR intervals in milliseconds; SDNN: standard deviation of all normal to normal RR intervals RMSSD: root mean square of successive RR interval differences; NN50: number of successive RR interval pairs that differ more than 50 msec; pNN50: the percentage of intervals >50 ms different from preceding interval; Triangularindex: The integral of the RR interval histogram divided by the height of the histogram; TINN: Baseline width of the RR interval histogram; VLF: very low frequency ; LF: low frequency; HF: high frequency; SD1: In Poincaré plot, the standard deviation perpendicular to the line-of-identity; SD2: In Poincaré plot, the standard deviation along the line-of-identity; SD2/SD1: Ratio between SD2 and SD1; PNS INDEX: Parasympathetic nervous system activity compared to normal resting value; SNS INDEX: Sympathetic nervous system activity compared to normal resting value; EE: energy expenditure; $p < 0.05$*; $p < 0.01$**, $p < 0.001$***; η^2: effect size; d: Cohen's effect size (effect size: ƫ- small effect, ƫƫ- intermediate effect, ƫƫƫ- large effect).

Discussion and Conclusion

In sport science settings, HRV analysis are used to assess the acute or chronic physiological effects of exercise, and the responses obtained here are accepted as an important parameter in the autonomous regulation of the heart despite the genetic differences (Kaikkonen, et al. 2008). According to the study conducted by Aras et al. (2014), the values taken after 30 minutes and 24 hours after the 1 hour running exercise of the adults who participated in the study were significantly higher than before the running exercises.

According to the results of the present research, a significant difference was found between HRV measured during the chess competition and running exercise. Although we hypothesized that the chess players would have a similar HRV indications during the competition and continuous running exercise, HRV was found to significantly differ according to the results of the current study. Furthermore, a significant difference was found between the energy (calories) expenditure during the chess game (138.1 ± 65.8 kcal) and the running exercises (260.5 ± 109 kcal) of the participants. Therefore, the energy expenditure during the chess competition is not as high as during running exercises.

In conclusion, according to the heart rate variability data, chess competition and running exercise are significantly different from each other. Running exercise is lower than HRV chess game. Another result is that running exercise requires more energy than chess game.

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