Heart rate variability and its fluctuations due to personality type, anxiety, aerobic capacity and body composition in skill sport athletes.

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Abstract

Objective: The present study was carried out to understand the relationship of heart rate variability (HRV) with body fat percent, skeletal muscle content, total body water, vO_2max, personality traits and levels of state and trait anxiety in archers.

Materials and Methods: The present cross-sectional study was carried out on 59 archers, of which 34 were males (age 18.9 ± 2.2 years) and 25 females (age 18.8 ± 2.2 years). The archers were tested for body fat percent, muscle content, total body water, physical capacity (vO_2max), heart rate variability (SDNN, pNN50, LF, HF, LF/HF), type of personality and levels of state and trait anxiety using standard protocols.

Results: Significant positive correlation was found between age and pNN50 (ρ=.307, p=.018); years of training and HF (ρ=.284, p=.030). Total body water, vO_2max, extraversion and open mindedness traits of personality showed positive significant relationship with time domain measures of HRV. Open mindedness was also positively related to HF HRV (ρ=.366, p=.004). Multiple regression analysis showed significant impact of these variables on SDNN and pNN50.

Conclusion: Age, training years, percentage of body water, vO_2max, and personality found to affect heart rate variability in archers.

Keywords: *heart rate variability, vO_2max, archery, personality, total body water*
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Introduction

Archery is a skill game that requires great precision with the repeated performance of technique of shooting for hours. Thus, the physical and physiological demands of archery are different when compared to other sports. Archers require high muscular strength and endurance in upper body for the performance of technique as it is seen that an average force required to pull the bow is 18-20 kg (Savvides, Giannaki, Vlahoyiannis, Stavrinou, Aphamis, 2020). It is important for archers to maintain good level of hydration as dehydration negatively impacts muscular endurance and thus might affect performance (Barley, Chapman, Blazevich, Abbiss, 2018).

Physical fitness of an athlete can be measured by means of aerobic capacity. Many researchers have established that vO_2max is the best measure of aerobic capacity (Rankovic, 2010). It is established that archers are lower vO_2max values as compared to athletes of other sports. Successful archers have been reported to exhibit higher values of vO_2max, handgrip strength, height and arm span (Lau, Ghafar, Hashim, Zulkifli, 2020). Maintaining a stable posture and good static balance is utmost importance for success in archery.

For success in the sport of archery, maintaining a low heart rate during shooting is an important characteristic. Higher heart rate has been shown to increase tremors and thus might lead to decrease in shooting accuracy. There are many physical and mental stressors that might lead to increased heart rate. An archer must learn to control these stressors to maintain heart rate in an optimal range. Dehydration is one physical factor that can increase heart rate during long

hours of shooting in competitions (Savvides et al., 2020).

Archers need to have good eye-hand coordination and concentration to be successful. Personality traits of extraversion and neuroticism have been shown to have good coping abilities and thus beneficial for archers (Musa et al., 2019). Extraversion, level of motivation and attention in archers have been shown to improve their performance (Parsaie, Abdoli, Vaez, Aslankhani, 2013). Personality can affect autonomic function and dynamics. Increased neuroticism is linked to increased SNS activation, as measured by increased electro-dermal response. Individual differences in the big five personality traits are linked to individual differences in electrocardiogram (ECG) amplitude patterns, in particular high neuroticism and low positive emotion (Koelsch, Enge, & Jentschke, 2012).

Mourot et al. have shown that athletes exhibit an increased HRV profile and parasympathetic modulation as compared to sedentary subjects (Mourot L, Bouhaddi M, Tordi N, Rouillon JD, Regnard J., 2004). In 2013, Grant et al. published a study to find out association of HR, RR, RMSSD, pNN50, LF, HF, LF/HF, SD1, and SD2 with vO_2max and they found that the most important predictor of cardio vascular fitness and exercise ability, as represented by VO_2max, was HR (Grant et al., 2013). HF HRV has been shown to be associated with muscle content, physical activity levels and central adiposity (Andrew et al., 2013).

The aim of the present study was to understand the relationship of personality traits, levels of state and trait anxiety, physical fitness and body composition with heart rate variability in archers. A comparative analysis between male and female archers with respect to heart rate variability, type of personality, body composition and aerobic capacity was done to understand important characteristics for successful archers.

Methodology

Participants

The present cross-sectional study was carried out on 59 archers out of which 35 were males (age 18.9 ± 2.2 years) and 25 females (age 18.8 ± 2.2 years). The athletes had a history of participation in at least national level competitive events with minimum of 2 years formal training and were in pre- competitive phase during the conduction of the test. Subjects, who were healthy, with no history of any hereditary or cardio-respiratory diseases, were selected for the study. Prior to that, a full explanation of the purposes, procedures and potential risks and benefits of the assessments were offered to all players, and their written consents were acquired. The present study was conducted following guidelines as laid down in the Declaration of Helsinki, and ethical clearance was also obtained from the Institutional Ethical Committee before performance of any tests on human subjects.

Procedure

All subjects were assessed for various physical, physiological and psychological variables at Human Performance Laboratory, SAI and conducted during morning hours on similar day. They underwent heart rate variability assessment first and then physical and questionnaire based psychological assessments were done followed by sub-maximal exercise testing with the help of bicycle ergometer after familiarizing them with the exercise protocol. The subjects were asked to have a light meal at least 2 hours before the test. The training was relatively common to all the athletes of the study besides the skill training. Their medical history and training duration was evaluated by a pre-set questionnaire.

The height and weight were measured using digital measuring station (SECA 284; SECA, Hamburg, Germany). Heart Rate Variability (HRV) was measured using Physiological Monitoring System (Zephyr Technology Corporation, Annapolis, MD, US) (Kim et al., 2013). The chest strap was tied across the chest of the subject such that the centre of the electrode was directly beneath the subject's armpit. The subject was seated in a comfortable arm-chair located in a quiet laboratory, and was asked to remain as still as possible for the duration of the recording. The readings were taken for duration of 10 min, out of which last 5 min readings were considered for analysis. The values of the RR intervals were analysed using Kubios Software (Version 2.2, Kuopio, Finland) (Tarvainen et al., 2014).

Body composition analysis was done using Body Composition Analyser (BCA) (Model mBCA 515,

SECA, Hamburg, Germany) (Lahav, Goldstein & Gepner, 2021). The subjects were instructed to come for the test fasting and with empty bladder, and all metal accessories, coins and mobile phones removed from the body. The subjects were made to stand on the platform with electrodes such that, their heels were placed central to the smaller posterior electrode, and forefoot was placed central to larger anterior electrode. The subjects were asked to touch the electrodes in such a way that the electrode separator was located between middle and ring fingers.

Aerobic capacity of the subjects was measured using the Astrand protocol on bicycle ergometer (Monark LC7). The subject cycled for 6 minutes at a workload chosen to try and elicit a steady-state heart rate between 125 and 170 bpm. Recording of the heart rate was done every minute during the test. If the heart rate at 5 and 6 minutes was not within 5 beats/min, the test was continued for one extra minute. The steady-state heart rate and workload recorded were put in the equation to determine an estimation of VO_2max (Macsween, 2001). For the characterisation of the personality type Big Five Inventory was used, which is a 44-item inventory that measures an individual on the dimensions of personality namely, extraversion, agreeableness, openness, neuroticism and conscientiousness (Goldberg, 1993). The State-Trait Anxiety Inventory (STAI) was used for the measurement of trait and state anxiety levels (Spielberg et al., 1983).

Statistical Analysis

The normality of data was checked using the Shapiro Wilk test and the data was found to be non-parametric in nature. Spearman's correlation coefficient was used in order to test the relationships of physiological and psychological parameters with heart rate variability. Multiple linear regression models analysed the effects of HRV parameters of SDNN and pNN50 on different physiological and psychological parameters. Comparison of physiological and psychological parameters in males and females was done using Mann-Whitney U Test. Statistical analysis was carried out using the SPSS v23.0 package (SPSS Inc., Chicago, IL, USA). Significance was considered at an alpha level of $p \leq 0.05$.

Results

Table 1 represents physical, physiological and psychological parameters in male (n=34) and female (n=25) archers. Male and female archers were matched for age with mean age 18.8 years of females and 18.9 years of males. Significant differences in fat percent, muscle content, total body water and vO2max were found between males and females. Females had high levels of fat percent (28.9±6). Males showed higher levels of skeletal muscle mass (28±3.5 kg), total body water (60.6±4.5 %) and vO_2max (43.3±6.2 ml/kg/min). No significant differences were found in personality traits and levels of anxiety in between females and males. Only one parameter of HRV, pNN50 showed significant difference (p=0.038) between females (10.9±13.1) and males (14.9±13.3).

Table 1: Physical, physiological and psychological parameters of female and male archers.

Parameter	Females (n=25)	Males (n=34)	Sig.
Age (years)	18.8±2.2	18.9±2.2	0.822
Years of Training (years)	5.3±2.2	5.6±2.1	0.647
Height (cm)	162.3±4.3	173.9±5.9	0.000*
Weight (kg)	60.4±8.6	69.6±10.7	0.001*
Fat Percent (%)	28.9±6.0	16.3±6.4	0.000*
Muscle content (kg)	19.3±2.0	28.0±3.5	0.000*
Total Body Water (%)	52.2±4.2	60.6±4.5	0.000*
vO_2max (ml/kg/min)	36.7±4.3	43.3±6.2	0.000*
SDNN (ms)	65.3±20.0	82.1±40.4	0.145
pNN50	10.9±13.1	14.9±13.3	0.038*
LF (n.u.)	54.9±15.8	61.1±12.2	0.123

HF (n.u.)	45.1±15.8	38.9±12.2	0.127
LF/HF	1.7±1.8	1.9±1.4	0.137
Extraversion	27.6±3.9	27.4±3.4	0.951
Agreeableness	36.3±4.9	34.3±5.5	0.118
Conscientiousness	35.5±3.9	34.6±4.4	0.264
Neuroticism	23.1±5.0	23.2±4.3	0.890
Open Mindedness	37.7±3.8	37.3±4.0	0.871
State Anxiety	37.8±8.9	38.3±10.0	0.854
Trait Anxiety	43.4±8.8	42.9±10.4	0.951

* - Significant
SDNN - Standard Deviation of NN intervals
pNN50 - Percentage of consecutive NN intervals greater than 50 msec.
LF - Low Frequency
HF - High Frequency
LF/HF – Ratio of Low Frequency over High Frequency

Table 2 represents Spearman's correlation coefficients between time domain and frequency domain measures of HRV and body composition, aerobic capacity, personality and anxiety among archers. We found a positive correlation of age in years with pNN50 parameter of HRV (ρ=.307, p=.018). Duration of formal training of archers in years was also found to be related with frequency domain measures of HRV; having significant positive correlation with HF (ρ=.284, p=.030). In body composition parameters only total body water was observed to be positively related with pNN50 (ρ=.256, p=.050). vO_2max with SDNN (ρ=.428, p=.001) and pNN50 (ρ=.316, p=.015) showed positive significant correlations. Persoanlity traits of extraversion and open mindedness were found to bear correlations with HRV as represented in Table 1. State and trait anxiety did not show any correlations with HRV in archers.

Table 2: Spearman's Correlation Coefficient of HRV with different physiological and psychological parameters.

	SDNN	**pNN50**	**LF**	**HF**	**LF/HF**
Age (years)	.045$^{.733}$	**.307$^{.018}$**	.067$^{.615}$	-.069$^{.613}$	.067$^{.615}$
Years of training	.017$^{.896}$	.061$^{.648}$	**-.280$^{.032}$**	**.284$^{.030}$**	**-.280$^{.032}$**
Height (cm)	.130$^{.327}$	.235$^{.073}$	.073$^{.585}$	-.071$^{.595}$	.066$^{.621}$
Weight (kg)	.062$^{.643}$	.086$^{.515}$	.140$^{.289}$	-.139$^{.295}$	.138$^{.297}$
Fat percent (%)	-.218$^{.097}$	-.227$^{.084}$	-.083$^{.533}$	.083$^{.532}$	-.078$^{.556}$
Muscle content (kg)	.173$^{.190}$	.242$^{.065}$	.173$^{.191}$	-.171$^{.194}$	.168$^{.203}$
Total Body Water (%)	.224$^{.089}$	**.256$^{.050}$**	.047$^{.722}$	-.047$^{.723}$	.042$^{.751}$
vO_2max (ml/kg/min)	**.428$^{.001}$**	**.316$^{.015}$**	-.017$^{.901}$	.017$^{.901}$	-.023$^{.864}$
Extraversion	.247$^{.060}$	**.320$^{.013}$**	-.101$^{.445}$	.103$^{.440}$	-.107$^{.418}$
Agreeableness	.019$^{.884}$	.027$^{.839}$	-.005$^{.968}$	.002$^{.988}$	-.001$^{.993}$
Conscientiousness	.157$^{.234}$	.149$^{.259}$	-.110$^{.405}$	.113$^{.395}$	-.110$^{.406}$

Neuroticism	-.134.312	-.046.727	.192.144	-.187.156	.189.152
Open Minded	**.319.014**	**.257.049**	**-.362.005**	**.366.004**	**-.368.004**
State Anxiety	-.239.069	-.149.261	.051.699	-.049.715	.052.698
Trait Anxiety	-.129.331	-.056.673	.117.378	-.112.397	.117.379

SDNN – Standard Deviation of NN intervals
pNN50 – Percentage of consecutive NN intervals difference greater than 50 msec.
LF - Low Frequency
HF - High Frequency
LF/HF – Ratio of Low Frequency over High Frequency

Table 3: Multiple linear regression analysis to evaluate possible predictors of SDNN and LF/HF.

	R	**R^2**	**F (15,43)**	**Sig F-chg**	**Beta**	**t-value**	**p-value**	**Collinearity Statistics**	
								Tolerance	**VIF**
SDNN (ms)	.720	.518	3.083	.002					
Age (years)					-.007	-.060	.953	.751	1.331
Years of training					-.159	-1.392	.171	.858	1.166
Height (cm)					-.506	-2.373	.022	.247	4.053
Weight (kg)					-.139	-.356	.724	.073	13.608
Fat percent (%)					.426	.408	.685	.010	97.137
Muscle content (kg)					.678	1.463	.151	.052	19.174
Total Body Water (%)					.317	.310	.758	.011	93.032
vO2max (ml/kg/min)					.544	3.748	.001	.531	1.883
Extraversion					.282	2.260	.029	.722	1.385
Agreeableness					.070	.443	.660	.448	2.233
Conscientiousness					.212	1.538	.131	.590	1.694
Neuroticism					.192	1.305	.199	.516	1.937
Open Minded					.261	2.193	.034	.790	1.267
State Anxiety					.018	.116	.908	.442	2.261
Trait Anxiety					-.103	-.669	.507	.475	2.106
	R	**R^2**	**F (15,53)**	**Sig F-chg**	**Beta**	**t-value**	**p-value**	**Collinearity Statistics**	
								Tolerance	**VIF**
pNN50	.704	.496	2.819	.004					
Age (years)					.298	2.387	.021	.751	1.331
Years of training					-.111	-.953	.346	.858	1.166
Height (cm)					-.264	-1.209	.233	.247	4.053
Weight (kg)					-.211	-.528	.600	.073	13.608
Fat percent (%)					3.410	3.195	.003	.010	97.137
Muscle content (kg)					.647	1.364	.180	.052	19.174

Total Body Water (%)					3.106	2.974	.005	.011	93.032
vO2max (ml/kg/min)					.412	2.772	.008	.531	1.883
Extraversion					.338	2.651	.011	.722	1.385
Agreeableness					-.024	-.150	.881	.448	2.233
Conscientiousness					.018	.130	.897	.590	1.694
Neuroticism					.253	1.682	.100	.516	1.937
Open Minded					.272	2.228	.031	.790	1.267
State Anxiety					-.022	-.138	.891	.442	2.261
Trait Anxiety					-.015	-.095	.925	.475	2.106

SDNN – Standard Deviation of NN intervals
LF/HF – Ratio of Low Frequency over High Frequency

In order to further examine the relationship between heart rate variability (HRV) measures and body composition, physiological and psychological parameters linear multiple regressions were performed to evaluate the possible predictors of SDNN and pNN50 parameters of HRV as shown in Table 3. The first multiple regression model used SDNN parameter of HRV as the dependent variable, and age (years), training years, height (cm), weight (kg), fat percent (%), muscle content (kg), total body water (%), vO_2max (ml/kg/min), big five traits of personality and state and trait anxiety as independent variables. Results showed that all of these predictors produced R=0.720, R^2=0.518, F(15,43)=3.083, p=0.002, stating that all independent variables explained 51.8 % of their SDNN. However, beta coefficients indicate that height (beta=-0.506, t=-2.373, p=0.022), vO_2max (beta=0.544, t=3.748, p=0.001), extraversion (beta=.282, t=2.260, p=.029) and open mindedness (beta=.261, t=2.193, p=.034) significantly predict SDNN.

Second linear multiple regression was performed with pNN50 time domain parameter of HRV as dependent variable, and age (years), years of training, height (cm), weight (kg), fat percent (%), muscle content (kg), total body water (%), vO_2max (ml/kg/min), extraversion, conscientiousness, neuroticism, agreeableness and open mindedness traits of personality and state and trait anxiety as independent variables. Results showed that all of these predictors produced R=0.704, R^2=0.496, F(15,43)=2.819, p=0.004, stating that all independent variables explained 49.6 % of pNN50. However, beta coefficients indicate that age (beta=0.298, t=2.387, p=0.021), body fat percent (beta=3.410, t=3.195, p=.003), total body water (beta=3.106, t=2.974, p=.005), vO_2max (beta=0.412, t=2.772, p=0.008), extraversion (beta=.338, t=2.651, p=.011) and open mindedness (beta=.272, t=2.228, p=.031) significantly predict pNN50.

Discussion

Archery is a game of skill and requires a lot of attention and concentration. Although, stress and anxiety are detrimental for all sporting activities, they can have significant effect in skill sports such as archery and shooting. Researchers say that higher heart rate during shooting leads to low scoring in archery. Heart rate variability study in archers demonstrate that well trained archers have better autonomic control as compared to novice archers (Aggarwala, Dhingra, 2017). The present study was conducted with the aim to understand the effects of training on heart rate variability as a result of changes in body composition, physical fitness, personality and levels of anxiety. Our results support the hypothesis that correlation does exist between HRV and physiological and psychological parameters in archers.

Extraversion trait of personality reflects an individual's response to positive stimuli and is indicative of assertiveness, excitement and gregariousness (McCrae et al., 2000). We found moderately positive significant relationship between extraversion personality type and pNN50 (p=0.013). Open mindedness showed significant relationships with both time domain and frequency domain parameters of HRV. Open mindedness demonstrated positive relationship with HF parameter of HRV (ρ=.366, p=.004) signifying that open minded personality type

individuals have dominance of parasympathetic system over sympathetic autonomic nervous system. Previous researches support our results showing negative correlation of openness with RMSSD and HF measures of HRV. This might suggest that a more developed and mature character is related with parasympathetic activity (Cloninger & Zohar, 2011).

Multiple linear regression of SDNN (Table 3) shows that variables like age, height, weight, training years, fat percent, muscle content, total body water, aerobic capacity, personality traits and anxiety are major predictors of SDNN (R^2=.518). Height showed significant negative impact on SDNN. Aerobic capacity (vO_{2max}), extraversion and open mindedness had the most positive effect on SDNN among all the parameters. Negative correlation of height with heart rate and body mass index with heart rate variability have previously been reported in healthy adults (Lutfi, Sukkar, 2011). Multiple linear regression analysis of pNN50 shows that all the above mentioned independent variables predict pNN50 with R^2 value of 0.496. Age, fat percent, total body water, vO_2max, extraversion and open mindedness had significant and positive impact on pNN50. Levels of anxiety negatively affected pNN50 although their effect was not very significant.

We found significantly positive relationship between vO_2max and SDNN (ρ=.428, p=.001) and pNN50 (ρ=.316, p=.015) parameter of HRV. In 2013, Grant et al. found significant correlation between pNN50 and vO_2max. With the help of regression analysis they explained that relation between vO2max and HRV (pNN50) was mainly due to the relation between vO2max and heart rate (Grant, Murray, Janse van Rensburg & Fletcher, 2013). HF HRV which is an important marker for parasympathetic inhibition over sympathetic control has been found to be related to markers for muscle content, central adiposity and physical activity levels (Andrew et al., 2013). In a study conducted on sedentary individuals, no correlation was found between vO_2peak and spectral components of HRV, only a weak relationship was found between vO_2peak and SDRR (Colflesh et al., 1997). In another study, high correlation between vO_2peak and non-normalized HF power was seen among men and women having varying levels of fitness (Goldmith et al., 1997). Dishman et al. reported that heart rate variability may be sensitive to recent experiences of emotional stress, but not affected by their levels of physical fitness (Dishman et al., 2000).

Due to long standing hours in competition and during training it is important to maintain optimal levels of hydration for archers. Dehydration can also negatively impact mood and increase stress, anxiety and fatigue (Savvides et al., 2020). Total body water was found to be positively related pNN50 in archers. In our study, we did not find any significant relationship of state anxiety and trait anxiety with time domain and frequency domain parameters of heart rate variability in archers. In a study conducted on physically active adults of age 25-40 years, no relationship was found between trait anxiety and HF and LF components of HRV (Dishman et al., 2000).

Conclusion

The present study is a novel study in archers to understand the fluctuations in heart rate variability due to physical, physiological and psychological effects of training. Training years, age, height, total body water, vO_2max, extraversion and open mindedness were found to have significant effects on time domain and frequency domain parameters of heart rate variability (HRV). It is also interesting to note that no significant differences in personality and levels of anxiety between male and female archers was seen. However, it is suggested to replicate the study on a greater sample size and archers from different regions to make the results more generalizable.

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