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To Assess and Correlate Resting Heart Rate, Body Composition and Heart Rate Variability in Judo and Wushu Players

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ABSTRACT

Background: This study aimed to compare and correlate the resting heart rate, body composition and heart rate variability among judo and wushu players.
Method: 40 athletes (20 judo and 20 wushu players) were included in the study. Body composition (BMI, subcutaneous body mass, skeletal body mass, body fat %, body density, Visceral fat, Lean body mass) was evaluated with the help of 7 skinfold thickness and body circumferences with the help of Harpenden calliper and measuring tape respectively. HRV (RMSSD, SDNN, LF/HF, LFnu and HFnu) was recorded in resting state (~5min) with the help of Heart wear shimmer ECG device.
Result: No significant difference of body composition and HRV variables (p> 0.05) was found between the two groups except Body fat % and body density (p<0.05) which differ significantly among the two groups. In Judo, LF/HF and LFnu showed significant positive correlation with BMI (p<0.05, r=-0.488), subcutaneous whole-body mass (p<0.05, r=-0.464), visceral fat (p<0.05, r =-0.508), and body fat % (p<0.05, r =-0.626. Whereas HFnu showed significant negative correlation with BMI (p<0.05, r=-0.488), subcutaneous whole-body mass (p<0.05, r=-0.464), visceral fat (p<0.05, r=-0.505) and body fat % (p<0.05, r=-0.626). Whereas no correlation was found between HRV and Body composition in wushu players.
Conclusion: Reduction in body fat % and visceral fat in judo players indicate improved sympathovagal balance which can be due to the adaptation induced by training loads. Similar results were not seen in wushu players because of high amount of body fat% and visceral fat.

Keywords: Body composition, combat sports, heart rate variability, Body fat %, resting heart rate.

INTRODUCTION

Combat sports have unique characteristics in comparison to other sports as two athletes are involved in a regulated form of one-on-one fight in which they attempt to directly attack the opponent by using various techniques, tactile excellence and physical fitness specially strength, muscle power and speed. [(1,2)]

Combat sports have been classified as grappling (brazilin jiu-jitsu, judo, wrestling) striking (boxing, karate, taekwondo) and mixed (wushu, ju-jitsu) depending on their action and the rules.[(2)] Technique used by players differ in both type of sports as grappling mainly involves projections, throws, immobilisation and joint lock. Whereas, striking involves punches, kicks, elbows and knee blows.[(3)] Traditionally, it has been seen that athletes who grapple have high anaerobic capacity, strength and low body fat %. Whereas, athletes who strike have high aerobic capacity, flexibility and an above average anaerobic power.[(4)] Judo and wushu both are dynamic and high intensity intermittent sports requiring a diverse physical and physiological profile to be successful in competition.[(5)] Physiological demand of these sports challenge both the aerobic and anaerobic systems as anaerobic system provide energy during the short, quick, all-out bursts of maximum power during match, while aerobic system contributes to athlete's ability to recover during the brief period of rest during the match and promote an effective recovery between the matches. [(6)]

Combat athletes are divided into body weight categories Currently, there are seven weight categories in judo for males (<60 kg, 66 kg, 73 kg, 81 kg, 90kg, 100 kg and >100 kg)[(5)] Maintaing an optimal body mass and body composition define an athletes' best weight category different body composition among athletes can influence the type of techniques applied during a match [Franchini *et al.* 2005b, 2014b]. For instance, the low body fat percentage is associated with higher anaerobic capacity and higher number of attacks [Franchini *et al.* 2005a] leading to improvement in physical performance and competition results (Mello and Fernandes Filho 2004) [(7)] In addition, studies have shown higher levels of body fat is negatively correlated with performances, techniques, strength, endurance and muscular force and power.[(8)] Scarce santos et al. did utilise DEXA for estimating body fat percentages in grapplers and strikers and found 12.2% in males and 23.0% in females among the grapplers whereas, in strikers it was 12.9% in males and 27.6% in females (Santoset al.2014) [(9)] Athletes try to maximize their lean body mass and have very low levels of body fat and high level of muscle mass with the exception of heavyweight athletes enabling them to generate more power and perform fast and explosive movements during the match leading to improved performance and higher chances to win a match [Monteiro *et al.* 2011]. In terms of somatotype, Combat sport athletes generally thought to have a profile that accentuates the mesomorphic properties (very high muscularity and low fat).[(5)] It has been seen that male athlete with less than 10% of body fat were able to obtain better results [Franchini *et al.* 2011]

Resting heart rate is simple and non-invasive clinical method that can be used to monitor fitness of an individual. Athletes tend to have higher cardiorespiratory fitness, muscle strength and flexibility levels due to neural and muscular adaptations resulting in predominance of parasympathetic system reflected in lower resting heart rate. In contrast to that excess body fat lead to release of inflammatory adipokines into the bloodstream, associated with increased sympathetic nervous system activity resulting in increased resting heart rate.[(10)]

Heart rate variability is the fluctuation in the time interval between the adjacent heartbeat it depends on R-R interval duration i.e., shorter the interval, smaller the range of heart rate variability. It has been observed that increase in sympathetic drive reduce the duration of R-R interval, reducing HRV. Conversely, increase in parasympathetic activity led to an increase in the R-R interval duration and enhanced HRV. [11]Monitoring of HRV can be done for 24 hrs, short term (~5min) or brief, ultrashort (UST, <5min) by using time domain, frequency domain and non-linear measurement method. Time domain indices of HRV quantify the amount of variability in interbeat interval i.e., the time period between the successive heartbeat. Whereas, frequency domain estimates the distribution of absolute and relative power into 4 frequency bands. The Task force of European society of cardiology and the north America society of pacing and electrophysiology (1996) divided heart rate oscillations into ultralow frequency (ULF), Very low frequency (VLF), low frequency (LF) and high frequency (HF). Each frequency band denote different parameter of autonomic nervous system as parasympathetic efferent activity is considered responsible for HF, both sympathetic and parasympathetic outflow are considered to determine LF whereas LF/HF ratio indicates the fractional distribution of power. [(11)]

HRV is becoming one of the most used training and recovery monitoring tool in sports and can be useful for tracking adaptations/maladaptations, internal effects of exercise on an athlete, to prevent and diagnose overtraining (OT) syndrome, in detection of non-functional overreaching (NFOR) and early identification of overtraining and fatigue in professional athletes in order to design fitness programs that ensure sufficient training load corresponding to athlete's ability. [(12)]

Although combat sports are popular, only few studies are available on physical, anthropometric and physiological profile of combat sports.

Thus, the study will compare and correlate Resting heart rate, body composition and heart rate variability in judo and wushu players enabling us to monitor the training load, adaptations and internal effect of exercise on athletes which will help to know the diverse physical and physiological profile of combat athletes.

METHODOLOGY

Participants

This study included 40 male athletes divided into 2 groups, Group I (Wushu, n=20) and Group II (Judo, n=20) by convenient sampling method. All the athletes included in this study were national and international level players. Inclusion criteria for participation in this study were the following:- (1) 18-25 years of age, Male (2) Subjects with minimum 1 year of experience (3 Willingness to give informed consent. Subjects having any medical history of unstable angina, recent cardiac infarction, uncontrolled hypertension, autonomic dysfunction, diabetes, metabolic syndrome, premorbid respiratory condition like asthma, COPD, restrictive lung disease and a history of alcohol consuming or smoking, tobacco intake, heavy caffeine addict were excluded from the study. All the subjects were explained about the purpose and methodology and possible risks of the study, and informed consent was taken.

Testing procedure

All the athletes were tested on their recovery day. The assessment was scheduled in the morning hours between 9AM-12PM. All the variables were measured on one day it was carried out in a quiet and comfortable room with temperature maintained around 25 to 28^{o} C. Vitals like Blood pressure, resting heart rate and SPO2 were measured; Height, weight, BMI and all the demographic details were recorded. Heart rate variability (HRV) was measured under controlled circumstances. Subjects were pre informed about not eating or drinking caffeinated beverages at least two hours before the testing and to avoid any physical activity to prevent alteration in the heart rate.

After the HRV test, anthropometric profiling was done with the help of anthropometric tape and Harpenden calliper.

Measurement of HRV

The HRV measurement was performed using a Heartwear Shimmer ECG device by EsMedTek, Consensys software for recording and sinusCor for the analysis of the HRV. The procedure followed the recommendations of the Task Force.

The HRV was recorded in resting state in sitting position. All the subjects were instructed to maintain calm and normal breathing pattern and temperature of the room was maintained. To maintain the quality of the HRV recording and to minimise the likelihood of signals interference from electrodes falling off or sporadic contact caused by hairs or dirt particles, it was ensured that all the participants shaved off their chest hair for good electrode to skin contact. Also, the skin was cleaned to remove oils and sweat so that interferences of the signals can be avoided. The 5 electrodes were taken in which the two electrodes were placed at 2cm below the clavicle (midclavicular line) on the right and left side. Rest two electrodes were placed two finger breadths above the ASIS on the right and left side. The remaining one electrode was placed over the 4-5th intercostal space. The machine was simultaneously connected to Consensys software via Bluetooth in laptop and HRV was recorded. First 2 minutes of ECG was recorded to lookup for observation and then actual ECG was recorded for 5 minutes. While the participants were seated, parameters of HRV analysed were: Mean and standard deviation of heart rate (HR) in beats per minute(bpm); mean RR intervals (RMSSD), standard deviation of NN interval (SDNN), low frequency spectral (LF) component; high frequency spectral component (HF); low frequency/high frequency (LF/HF) ratio.

Anthropometric Profiling and Body Composition

The height and weight were measured for each subject while they were wearing light clothing (shorts) and no shoes and socks, maintaining privacy in a controlled room temperature.

Weight was measured to nearest 0.1Kg using calibrated scales, while the height was measured to the nearest 0.1cm using a calibrated stadiometer/ anthropometry rod.

An Anthropometry tape -Lufkin (W606PM) with an accuracy of ±1mm was used to measure the circumference of the waist, hip, abdomen, thigh and calf. To estimate the body fat percentage a seven-site skinfold thickness technique was used with a scientific skinfold calliper-Harpenden callipers by ISAK to the nearest 0. 1mm.The anatomical sites used were:- Pectoral, abdomen, quadriceps, triceps, suprailiac, subscapular and Midaxilla. Body density was estimated using the equation that has been validated for males aged 18 to 61 years (Jackson, A.S.& Pollock. (1978).

7 Site skinfold equation: Body density=1.112- (0.0004399×sum of skinfolds)+(0.00000055 ×square of the sum of skinfold sites)-(0.00028826 ×age). The body density estimates were in turn used to estimate the body fat percentage using the siri equation: [%Body fat=(495/body density)-450]. Fat mass was calculated by the transformation of the percentage body fat values [fat mass= (body mass×%body fat)/100]. Lean body mass was determined by the fractionation of body mass into two components: lean body mass=body mass-fat mass). Body mass and body fat percentage were measured using bioelectrical impedence analysis (Body composition Monitor Model HBF-375 machine, Omron). Two recordings were taken for each of the variables, and then average values were used to perform the statistical analysis.

Statistical Analysis

All statistical analysis was performed using SPSS version 25.0.

Data normality was confirmed with Shapiro Wilk test. The data set violated normality: therefore, Non-parametric tests were used in the study. We examined the difference between the judo and wushu group using Mann Whitney U test in which all the descriptive were presented as mean±SD. The correlation between resting heart rate, body composition and HRV variables was assessed by using Pearson correlation coefficient. The Statistical significance level was set at $P<0.05$.

RESULT

Based on the Mann Whitney U test result showed no significant difference between resting heart rate (U=, $n_1=n_2=20$, $p=0.091$), Subcutaneous Whole-Body mass (U=155.5, $n_1=n_2= 20$, $p=0.229$), Skeletal whole body (U=135, $n_1=n_2= 20$, $p =0.079$), Visceral fat % (U=172.5, $n_1=n_2= 20$, $p=0.456$) and BMI (U=154, $n_1=n_2= 20$, $p=0.213$) between the two groups.

While there was significant difference between Training duration/week (U=89.5, $n_1=n_2=20$, $p=0.002$), the Body fat % (7Skinfold) (U=113, $n_1=n_2= 20$, $p=0.019$) and Body density (U=113, $n_1=n_2= 20$, $p=0.019$) and Lean Mass (U=127, $n_1=n_2=20$, $p=0.048$) between the groups.

According to Pearson correlation, significant positive correlation was found between training duration/week and lean body mass in both groups (p<0.05, r=0.545, 0.508) respectively.

Table 1: Descriptive data of the two groups

	GROUP I (WUSHU)				GROUP II (JUDO)			
Variable	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**
Age	18	23	19.9	1.917	18	24	19.8	1.735
Experience	1	16	5.325	4.25	2	16	7.2	3.518
Category	48	85	66.85	10.5	45	100	70.95	12.327
Training Day	6	6	6	0	4	6	5.5	0.89
Training Duration/Day	2	6	3.47	1.21	2.5	8	5.425	1.549
Training Duration/week	12	36	20.85	7.25	15	48	29.55	9.64
Recovery Day	1	1	1	0	1	3	1.5	0.89
Height	164	185	171.37	5.46	160	184	171.37	6.6
Weight	53.4	95.1	70.85	11.33	51.1	97.5	74.88	12.03
BMI	19.5	29.8	24.08	3.42	18.1	33.5	25.44	3.65
Resting Heart Rate	56	94	75.8	11.33	45	93	68.75	12.73
SPO2	96	99	98.05	0.89	91	99	97.7	2.05

Table 2: Group Comparison (Mann Whitney U Test)

Variables	Mann Whitney U	Z	Asymp. Sig (2 tailed)
Resting Heart rate	137.5	-1.691	0.091
Experience	136.5	-1.726	0.084
Training Duration/week	89.5	-3.067	0.002
Subcutaneous Whole Body	155.5	-1.204	0.229
Skeletal Whole Body	135	-1.759	0.079
Visceral Fat %	172.5	-7.45	0.456
BMI	154	-1.245	0.213
Body Fat % (7-FOLD)	113	-2.35	0.019
Body Density (7-FOLD)	113	-2.353	0.019
Lean Mass	127	-1.975	0.048
Fat Mass	143	-1.542	0.123
RMSSD (ms)	190	-0.271	0.787
SDNN	191	-0.243	0.808
LF (ms2)	196	-0.108	0.914
HF (ms2)	183	-0.46	0.646
LF/HF	195	-0.135	0.892
LFnu	195	-0.135	0.892
HFnu	195	-0.135	0.892
HFnui	197	-0.081	0.935
LFnui	193	-0.189	0.85

Table 3.1: CORRELATION of GROUP I (WUSHU)

Variables		Correlation coefficient[r]	p Value (sig. 2 tailed)
LF/HF	Category	0.128	0.590
	BMI	0.268	0.254
	Subcutaneous Whole Body	0.259	0.269
	Weight	0.06	0.801
	Skeletal whole body	-0.344	0.138
	Visceral Fat %	0.297	0.203
	Body Density	0.044	0.855
	Body Fat %	-0.044	0.855
	Lean body Mass	0.042	0.855
LF nu	BMI	0.268	0.254
	Category	0.128	0.590
	Subcutaneous Whole Body	0.259	0.269
	Skeletal whole body	-0.344	0.138
	Visceral Fat %	0.297	0.203
	Body Density	0.044	0.855
	Body Fat %	-0.044	0.855
	Lean body Mass	0.042	0.86
HF nu	Category	-0.128	0.590
	BMI	-0.268	0.254
	Subcutaneous Whole Body	-0.259	0.269
	Skeletal whole body	0.344	0.138
	Visceral Fat %	-0.297	0.203
	Body Density	-0.044	0.855
	Body Fat %	0.044	0.855
	Lean body Mass	-0.042	0.860

In judo group, LF/HF and LFnu revealed significant positive correlation with weight category (p<0.05, r=0.467), BMI (p<0.05, r=0.488), subcutaneous whole-body mass (p<0.05, r=0.464), visceral fat (p<0.05, r=0.508), body fat % (p<0.01, r=0.626) and significant negative correlation with skeletal whole-body mass (p<0.05, r=-0.493), body density (p<0.01, r=-0.626).

HFnu revealed significant negative correlation with weight category (p<0.05, r=-0.467), BMI (p<0.05, r=-0.488), subcutaneous whole-body mass (p<0.05, r=-0.464), visceral fat (p<0.05, r = -0.508), body fat % (p<0.05, r = -0.626), fat mass (p,0.05, r=-0.571).

Significant negative correlation with body density (p<0.01, r=-0.626) skeletal body mass (p<0.05, r = -0.493).

Table 3.2: CORRELATION of GROUP II (JUDO)

Variables		Correlation coefficient[r]	p Value (sig. 2 tailed)
LF/HF	Category	0.467**	0.038
	BMI	0.488*	0.029
	Subcutaneous Whole Body	0.464*	0.040
	Weight	0.373	0.105
	Skeletal whole body	-0.493*	0.040
	Visceral Fat %	0.508*	0.022
	Body Density	-0.626**	0.003
	Body Fat %	0.626*	0.003
	Lean body Mass	0.305	0.191
LF nu	BMI	0.488*	0.029
	Category	0.467*	0.038
	Subcutaneous Whole Body	0.464*	0.040
	Skeletal whole body	-0.493*	0.027
	Visceral Fat %	0.508*	0.022
	Body Density	-0.626**	0.003
	Body Fat %	0.626**	0.003
	Lean body Mass	0.305	0.191
	Fat Mass	0.571**	0.008
HF nu	Category	-0.467*	0.038
	BMI	-0.488*	0.029
	Subcutaneous Whole Body	-0.464*	0.040
	Skeletal whole body	0.493*	0.027
	Visceral Fat %	-0.508*	0.022
	Body Density	0.626**	0.003
	Body Fat %	-0.626**	0.003
	Lean body Mass	-0.305	0.191
	Fat Mass	-0.571**	0.008

DISCUSSION

The study aimed to compare and correlate the resting heart rate, heart rate variability and body composition in judo and wushu players.

The result of the present study showed no significant difference of Resting heart rate, Subcutaneous Whole-Body mass, Skeletal whole body, Visceral fat%, BMI, RMSSD, LF (ms2), HF (ms2), LF/HFnu, LFnu and HFnu between the two groups.

While there is significant difference between the Training duration/week, Body fat%, Body density and lean body mass between the two groups.

In Judo group, Heart rate variability parameters i.e., LF/HF and LFnu showed significant positive correlation with weight category, BMI, subcutaneous whole-body mass, visceral fat%, body fat %. And significant negative correlation with skeletal whole-body mass.

Whereas the HFnu showed significant negative correlation with weight category, BMI, subcutaneous whole-body mass, visceral fat, body fat% and significant positive correlation with skeletal whole-body mass. In contrast to which no significant correlation was found between the heart rate variability parameters and body composition in wushu group.

Training duration/week revealed statistically significant positive correlation with Lean body mass in both the groups (p>0.05) indicating that athletes dedicating a greater number of hours to training will have more lean body mass. As the lean body mass contributes in the development of strength and power enabling the athletes to generate a greater amount of force, anaerobic power in a specific period of time also increased amount of lean body mass helps in boosting metabolism and make it easier to maintain the healthy weight which is an important factor in combat sports. Similar result was reported by Rishna dalui and Amit Bandyopadhyay supporting the result of our study that regular involvement in judo training reduce the body fat % and increased lean mass.[(13)]

Resting heart rate showed highly significant positive correlation with mean heart rate in wushu players. Whereas in judo players there was statistically significant negative correlation of resting heart rate with RMSSD, SDNN, Experience and training duration indicating the adaptations induced by the training loads over the period of time resulting in predominance of parasympathetic system these findings were similar to Patricia Souza Araujo et.al study who observed increase in absolute values of SDNN, RMSSD, PNN50, absolute LF, HF power demonstrating a predominance of parasympathetic modulation in judo athletes when compared to sedentary group. Previous study by Cristina Blasco- Lafarga et.al, also showed that athletes were capable of increasing their HR to a greater extent during physical activity as compared to sedentary individuals because of higher vagal modulation (i.e., high lnHF), low sympathetic modulation and chronic adaptations in athletes.[14] Another study by Orsolya Kiss et.al., goes with our study showing higher RMSSD, PNN50 and frequency domain in athletes when compared to the controls. [(10)]

In Judo Players, BMI showed statistically significant positive correlation with LF/HF, LFnu and significant negative correlation with HFnu indicating an increase in BMI will lead to increase in LF/HF and LFnu suggestive of autonomic dysfunction due to sympathovagal imbalance and an increased sympathetic activity respectively which can result in fatigue, overtraining and improper recovery in response to the training loads. Whereas, increase in HFnu is suggestive of predominance of parasympathetic activity due to the adaptations induced by the training loads leading to vagal mediated HRV. Our result goes with the other previous study (Tina Fohr et.al) which suggested that high level of physical activity and lower BMI were associated with lower amount of stress, better recovery during sleep contributing higher capacity to manage stress response creating sympathovagal balance leaning to vagal dominance.[(15)]

Visceral fat % showed no significant correlation with LF/HF, LFnu and highly significant negative correlation with HFnu in wushu players. Whereas in judo players Visceral fat% showed statistically significant positive correlation with LF/HF, LFnu and statistically negative correlation with HFnu. Reduction in visceral fat in judo and wushu players indicate improved sympathovagal balance and parasympathetic dominance which can be due to the adaptation induced by training loads A previous study also presented that heavyweight judo athletes had higher body fat % and more fat mass, especially visceral fat where Mean body mass of the heavyweight judo group was approximately 20 kg heavier, and mean of body fat % was approximately 8 % higher than those of the heavyweight football group. Additionally, Visceral fat of heavyweight judo group was about two times larger than that of heavyweight football group.[(16)]

Body fat % showed highly significant positive correlation with LF/HF and LFnu and highly significant negative correlation with HFnu suggesting that with increased body fat % there is reduction in the HRV variables resulting in sympathovagal imbalance leading to a sympathetic dominance. Several authors have stated that lower fat % in judo athletes are associated with high anaerobic power resulting in a greater number of attacks improving physical performance and competition results. Result of our study are similar to those remarked by Rishna Dalui and Amit Bandyopadhyay analysing that judo athletes had lower values of BMI, BSA, heart rate, systolic and diastolic blood pressure among them which is attributed to their regular participation in judo training. They found a negative correlation between Body fat % and performance in different categories (state level, national level etc) of judo athletes and concluded that reduction of fat % is associated with a simultaneous increase in aerobic capacity.[(13)]

Whereas, Wushu players showed no correlation of body composition and HRV variables due to increased amount of body fat% and reduced training duration/week, body density and lean mass leading to sympathovagal imbalance, sympathetic dominance and diminished ability to recover from the training stresses leading to poor adaptations to the training loads.

CONCLUSION

Judo athletes showed a significant correlation between body composition and heart rate variability parameters indicating that a low amount of body fat%, visceral fat%, subcutaneous whole-body mass and high skeletal mass lead to balanced sympathovagal balance, and predominance of vagal activity enabling athlete to recover faster from the training load and perform better due to the adaptations induced by the training loads over the period of time.

Wushu players showed no correlation of body composition and HRV variables due to increased amount of body fat % and reduced training duration/week leading to sympathovagal imbalance, sympathetic dominance and diminished ability to recover from the training stresses leading to poor adaptations to the training loads

Study Limitations

- The major limitation of this study is the sample size and only males were included in this study.
- Furthermore, we did not measure hormonal response with HRV which may influence the HRV.

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