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Linear Discriminant Analysis of Various Physiological and Psychological Parameters among Indian Elite Male Athletes of Different Types of Sports

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Abstract

The aim of this study was to categorize various physical, physiological, and psychological variables that discriminated among Indian elite male athletes participating in endurance sports (Group A, n=34, age=16.88±2.44 years), combat sports (Group B, n=35, age=17.40±1.37 years) and skill sports (Group C, n=34, age= 8.91±2.24 years) and non-athletic control group (Group D, N=33, years=18.48±2.03 years). Physical parameters included height, body weight, body fat percentage, lean body mass, muscle content, and total water content. Physiological parameters included heart rate variability and maximal aerobic power (VO2 max) measured using the Astrand protocol. Various psychological parameters were evaluated using Big Five Inventory and State-Trait Anxiety Inventory questionnaires. Discriminant analysis revealed three significant functions (P<0.05) contributing 65.7%, 25.8%, and 8.5% respectively to the model. After cross-validation, the resulting equation correctly classified 72.8% of endurance, combat, skill athletes, and control group. Total thirteen variables significantly (P<0.05) contributed to the discriminant analysis. The interpretation of the acquired discriminant functions was also based on the examination of the structure coefficients greater than 0.30. The athletes and control were discriminated mainly on VO2 max (structure coefficient, SC=0.741) in Function 1, body weight (SC=0.424), Lean body mass (SC=0.430), and muscle content (SC=0.574). This model substantiates the fact that elite male athletes show physical and physiological differences because of the different training regimens in their respective sports that conditioned them differently. In conclusion, these discriminant models could help in athlete's induction, talent identification process and improving training programs.

Keywords: *maximal aerobic power, linear discriminant analysis, endurance sports, combat sports, skill sports, psychological variables*

Introduction

Physical and physiological parameters have marked differences between athletes training for different sporting events and between different playing positions in team events (Matković et al., 2003). Understanding body composition of an athlete is important since it provides information on adaptations to training regimens and nutritional status. Different components of body composition, like fat mass, fat-free mass, and total body water, need to be studied since each component varies independently (Andreoli et al., 2003). Aerobic capacity is accepted as a major component of assessing the physical capacity of an athlete (Rankovic et al., 2010). The demand of oxygen differs from one sport to another sports (Singh and Patel, 2014). In football, hockey, basketball, and handball, technical and tactical skills as well as the physical performance capacity of the players are the most important factors that contribute to the success of a team in competitions. Combat sports that are shorter in duration and are comprised primarily of grappling

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or wrestling tend to require relatively lower aerobic capacity. Nevertheless, a greater aerobic capacity has been related to a higher standard of performance in boxing, wrestling, and judo too (James et al., 2016).

Heart rate variability (HRV) which is an indicator of cardiovascular autonomic regulation is an important determinant of training adaptations (Plews, Laursen, Stanley, Kilding, & Buchheit, 2013). In athletes, the autonomic balance is altered in response to varying intensities, and duration of the training, as measured by changes in HRV variables. Well-trained athletes have an elevated parasympathetic dominance as compared to non-athletes; confirming that athletic conditioning improves the autonomic control of the cardiovascular system (Dong, 2016). Combat sports athletes replicate high-intensity training and experience significant stress from losing weight before the match. This could have negative effects on the autonomic nervous function of combat sports athletes. According to an earlier study about on the heart rate variability of young archery athletes, experienced athletes had superior LF and RMSSD values during competition than beginners. This means that the parasympathetic nervous system of experienced archers is more dominant than beginners (Carrillo et al., 2011). In another study on the effects of heart rate variability on the performance of elite shooting athletes, the high-performance group had a lower SDNN than the low-performance group (Jon, 2015).

Physical capacity is not the only determining factor for success in sports, psychological capacity is equally important. Research has proved that personality differences were found between athletes and non-athletes, and also between individual- and team-sport athletes. It has been found that more successful athletes are significantly more agreeable, conscientious, and more emotionally stable than less successful athletes (Steca, Baretta, Greco, D'Addario, & Monzani, 2018). Optimal level of anxiety is also said to be beneficial for desired performance in sports. A statistically significant difference was found between the trait anxiety of athletes participating in different sports such as taekwondo and wrestling (Sanioglu, Ulker, & Tanis, 2017).

Many sports are based on a multifaceted, multi-dimensional performance profile (Buekers, Borry, & Rowe, 2015). There were promising efforts to discriminate various sports by means of their profile of sports-specific performance prerequisites. Leone, Lariviere & Comtois (2002) could differentiate 88% of athletes from four different sports (figure skating, swimming, tennis, and volleyball) by means of a discriminant analysis including anthropometric and motor characteristics. Even more promising were the findings of Pion, Fransen, Lenoir & Segere (2014) in elite male U18 athletes, as the investigators found a 100% correct classification within the more interconnected martial arts disciplines of judo, karate, and taekwondo. However, there is a lack of research exploring the discriminative value of different physiological and psychological performance fundamentals for Indian male elite athletes over a variety of different sports disciplines. Thus, the aim of this study was to investigate whether Indian male athletes participating in three different types of sports (endurance, combat, and skill) illustrate a sport-specific physiological, and psychological profile which is in line with the specific necessities of each sport that might serve as scientific knowledge backdrop for sports specific talent identification purposes.

Materials and Methods

Participants

The sample consisted of 136 male participants, divided into 4 groups. Group A (n=34, age=16.88±2.44 years, height=172.33±9.22 cm, weight=63.73±7.75 kg) included elite male athletes belonging to endurance sports such as middle and long-distance athletics, swimming, and cycling, Group B (n=35, age=17.40±1.37 years, height=170.66±10.01 cm, weight=71.06±15.98 kg) included elites male athletes belonging to combat sports such as wrestling and judo, Group C (n=34, age=18.91±2.24 years, height=173.99±5.96 cm, weight=69.66±10.69 kg) elites male athletes belonging to skill games such as archery and Group D (n=33, age=18.48±2.03 years, height=165.49±9.24 cm, weight=54.35±7.77 kg) included non-athletic population. Athletes were all selected from various schemes of Sports Authority of India (SAI), Northern Region and control group was composed of healthy university students who didn't participate in any sports. The athletes had a history of participation in at least national-level competitive events with a 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 (approval number SU/2021/092(30) dated 06.01.2021) before a 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 a 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 had a light meal at least 2 hours before the exercise 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 preset questionnaire.

Physiological and Psychological measurements

The height and weight were measured using a 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 center of the electrode was directly beneath the subject's armpit. The subject was seated in a comfortable armchair 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 a duration of 10 min, out of which the 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, Niskanen, Lipponen, Ranta-

Aho, & Karjalainen, 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 an 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 the 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 a 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 VO2max (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, Gorsuch, Lushene, & Vagg, Jacobs, 1983).

Although most of the tests administered are very standardized and well-documented assessments, test-retest reliability on the specific subject pool utilized in the present study could not be acquired. To counteract this possible problem, all testers were methodically trained and familiarized with proper test administration prior to actual data collection. All tests were DONE by the same tester to keep away from inter-tester errors. The discriminant analysis is considered to be robust with these variables (Norusis, 1993).

Statistical Analysis

Data analysis was done using the statistical program for social sciences (SPSS) version 25 SPSS (Inc., Chicago, IL, USA). In this study, the study variables were assessed by a two-tailed probability value of $p<0.05$ for significance. The data were tested for assumptions of normality using the Shapiro-Wilk test. Homogeneity of between groups variance-covariance matrix was checked using the Box M test. Discriminant analysis was employed on 18 variables measured, which included various physical, physiological and psychological parameters, to develop a model to predict membership of each athlete and non-athlete in the four groups (sports and non-sports). A discriminant analysis using the Wilks Λ was performed to determine the ability to discriminate between the four groups using the 18 selected variables ($p<0.05$). The interpretation of the acquired discriminant functions was based on the assessment of the structure coefficients greater than 0.30, meaning that variables with higher absolute values have a foremost contribution to discriminate among groups (Tabachnick & Fidell, 2000). Validation of discriminant models was carried out using the leave-one-out method of cross-validation (Norusis, 1993). Cross-validation analysis is required in order to comprehend the usefulness of discriminant functions when classifying new data. This method involves producing the discriminant function on all but one of the participants (n-1) and then testing for the group membership of that contributor. The process is repeated for each participant (n times) and the percentage of correct classifications created through averaging for the n trials.

Results

Means and standard deviations for the four groups of athletes and control are presented in Table 1. The global test for equality of the mean vectors for the four groups was significant (Wilk's Lambda, $P<0.01$), which showed that the groups were different in all variables except in fat (%), Conscientiousness, Agreeableness, Open-mindedness, and trait anxiety which yielded a statistically non-significant result (Table 2).

Table 1: Descriptive results from the physical, physiological and psychological variables of elite male athletes of different sports (values are mean± SD**)**

Variables	Group A Endurance (n=34)	Group B Combat (n=35)	Group C Skill (n=34)	Group D Control (n=34)
Age (years)	16.88±2.44	17.40±1.37	18.91±2.24	18.48±2.03
Training (years)	4.5±2.6	4.9±1.7	5.5±2.1	NA
Height (cm)	172.33±9.22	170.66±10.01	173.99±5.96	165.49±9.24
Weight (kg)	63.73±7.75	71.06±15.98	69.66±10.69	54.35±7.77
Fat (%)	13.50±5.34	14.38±5.67	16.29±6.36	15.07±6.25
Lean body mass (kg)	55.35±6.59	59.87±9.79	57.48±6.01	46.15±7.33
Muscle content (kg)	25.40±3.76	29.94±5.60	28.04±3.52	21.56±3.87
Total body water (%)	61.98±5.91	62.45±3.87	60.50±4.48	57.27±7.58
VO2 max (ml/min/kg)	59.22±5.59	51.33±6.14	43.27±6.16	41.29±4.28
SDNN	87.99±38.84	119.06±88.08	82.13±40.37	74.08±36.31
pNN50 (%)	28.90±17.25	23.14±19.41	14.96±13.20	25.38±18.82
LF/HF	2.28±1.51	5.28±8.35	1.95±1.45	2.36±1.85
Extraversion	28.88±3.71	29.51±3.92	27.44±3.43	26.96±2.67
Conscientiousness	35.58±4.86	34.82±3.84	34.58±4.40	33.18±5.12

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Table 1: Descriptive results from the physical, physiological and psychological variables of elite male athletes of different sports (values are mean± SD**)**

Variables	Group A Endurance (n=34)	Group B Combat (n=35)	Group C Skill (n=34)	Group D Control (n=34)
Agreeableness	35.82±4.86	36.02±3.30	34.29±5.49	36.72±3.33
Neuroticism	22.05±5.54	25.91±5.58	23.14±4.28	24.60±6.71
Open mindedness	37.88±2.91	37.42±3.79	37.29±4.03	38.54±3.82
State anxiety	32.94±7.06	39.97±9.39	38.29±10.04	38.30±7.09
Trait anxiety	41.17±8.12	43.45±8.85	42.88±10.38	40.87±8.73

* - significant at the level of <0.05;** - Significant at the level of <0.01, SDNN – Standard Deviation of NN intervals, pNN50 – Percentage of consecutive NN interval difference greater than 50 msec, LF – Low Frequency, HF – High Frequency, LF/HF – Ratio of Low Frequency over High Frequency, NA=Not applicable

Table 2: Test of equality of group means

Variables	Wilk's Lambda	F	df1	df2	Sig.
Age (years)	0.862	7.063	3	132	0.000
Height (cm)	0.882	5.881	3	132	0.001
Weight (kg)	0.738	12.632	3	132	0.000
Fat (%)	0.970	1.352	3	132	0.260*
Lean body mass (kg)	0.677	20.954	3	132	0.000
Total body water (%)	0.883	5.812	3	132	0.001
Muscle content (kg)	0.645	24.236	3	132	0.000
VO2 max (ml/min/kg)	0.379	72.117	3	132	0.000
SDNN	0.911	4.296	3	132	0.006
pNN50 (%)	0.918	3.953	3	132	0.010
LF/HF	0.913	4.189	3	132	0.007
Extraversion	0.916	4.009	3	132	0.009
Conscientiousness	0.964	1.652	3	132	0.180*
Agreeableness	0.959	1.867	3	132	0.138*
Neuroticism	0.934	3.124	3	132	0.028
Open mindedness	0.982	0.794	3	132	0.499*
State anxiety	0.909	4.411	3	132	0.005
Trait anxiety	0.985	0.663	3	132	0.576*

*statistically non-significant, SDNN – Standard Deviation of NN intervals, pNN50 – Percentage of consecutive NN interval difference greater than 50 msec, LF – Low Frequency, HF – High Frequency; LF/HF – Ratio of Low Frequency over High Frequency

The structure coefficients enumerate the potential of each variable to maximize differences between means amongst the endurance (Group A), combat (Group B), skill (Group C), athletes and control (Group D). The larger the enormity of the coefficients, the greater the contribution of that variable to the discriminant function. Multiple discriminant analyses revealed three significant functions (Table 3). Function 1 reflect an emphasis on VO2 max, function 2 on body weight, lean body mass, and muscle content while function 3 is on height, body weight, lean body mass, muscle content, pNN50, LF/HF, agreeableness and neuroticism (Table 3). Based on values of Wilk's Lambda, discriminant

Table 3: Discriminant function coefficients and tests of statistical significance

Variables	Structure matrix coefficient			Standardized discriminant functions		
	Function 1	Function 2	Function 3	Function 1	Function 2	Function 3
Age (years)	-0.217	0.088	-0.242*	-0.442	-0.070	-0.201
Height (cm)	0.116	0.092	-0.491*	-0.348	-0.665	-0.501
Weight (kg)	0.187	0.424*	-0.416	0.165	1.129	0.475
Fat (%)	-0.080	0.069	-0.146*	0.038	-0.379	-0.334
Lean body mass (kg)	0.276	0.430*	-0.419	0.621	-0.741	-0.612

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Table 3: Discriminant function coefficients and tests of statistical significance

Variables	Structure matrix coefficient			Standardized discriminant functions		
	Function 1	Function 2	Function 3	Function 1	Function 2	Function 3
Total body water (%)	0.198	0.128	-0.119	0.223	0.216	-0.266
Muscle content (kg)	0.232	0.574*	-0.339	0.039	0.907	0.192
VO2 max (ml/min/kg)	0.741*	-0.319	0.080	0.951	-0.337	0.082
SDNN	0.118	0.207*	0.182	-0.165	0.470	0.039
pNN50 (%)	0.079	-0.184	0.314*	0.029	-0.219	0.351
LF/HF	0.075	0.205	0.306*	0.250	0.195	0.226
Extraversion	0.166*	0.092	0.125	-0.107	-0.001	0.142
Conscientiousness	0.107	0.003	-0.124*	0.029	-0.003	-0.068
Agreeableness	-0.003	-0.067	0.322*	0.038	-0.027	0.502
Neuroticism	-0.034	0.175	0.308*	-0.132	0.029	0.659
Open mindedness	-0.034	-0.092	0.126*	0.073	-0.068	0.004
State anxiety	-0.094	0.250*	0.147	0.026	0.346	0.220
Trait anxiety	0.016	0.113*	-0.039	0.071	0.005	-0.360
Wilk's Lambda	0.093	0.351	0.735			
Chi square	294.420	129.676	38.217			
P	0.000	0.000	0.001			
Eigenvalue	2.776	1.091	0.361			
% of Variance	65.7	25.8	8.5			
Canonical correlation	0.857	0.722	0.515			

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

function 1 accounted for 65.7% of the variance, discriminant function 2 accounted for 25.8% of the variance, while discriminant function 3 accounted for 8.5% of the remaining variance among groups respectively.

Table 3 also provides a standardized discriminant function coefficient, an index of the importance of each predictor like the standardized regression coefficient (beta's) did in multiple regression. The sign indicates the direction of

Table 4: Functions at group centroids

Groups	Function		
	1	2	3
Endurance (A)	1.968	-1.255	-.161
Combat (B)	1.115	1.332	.512
Skill (C)	-.996	.579	-.901
Control (D)	-2.184	-.716	.551

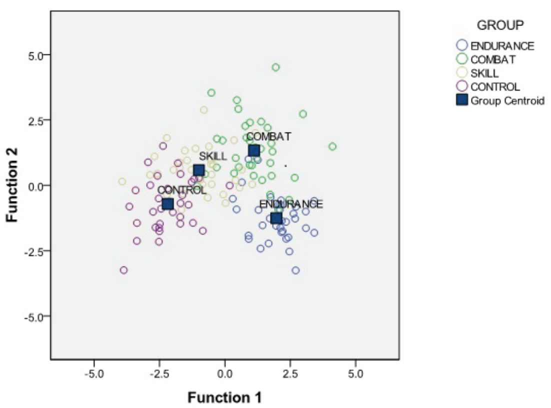

FIGURE 1. Plot of the individual and group differences between elite male athletes of different sports and control group resulting from different physical, physiological and psychological tests.

the relationship. The interpretation of the obtained discriminant functions was based on the examination of the structure coefficients greater than 0.30. VO2 max and muscle content are the strongest predictors of Function 1 and 2 respectively while state anxiety and extraversion are the least successful predictors of Function 1 and 2 respectively.

Based on these scores, group membership could be predicted according to the closeness of these respective group centroid values (mean group values) (Table 4). It is then possible to determine correct classifications. In our study, the endurance group has a mean of 1.968; the combat group has 1.115, skill group has -0.996 while control group has -2.184 in Function 1 while the endurance group has a mean of -1.255; combat group has 1.332, skill group has 0.579 while control group has -0.716 in Function 2 (Figure 1). Cases with scores near to a centroid are predicted as belonging to that group.

The original classification summary shows 81.6% of the cases correctly classified in their respective sports (table 5). The leave-one-out test summarizes the ability of the discriminant functions to correctly classify the athletes in their respective sports (see Table 5). This analysis provided an overall percentage of successful classification of 85.3% for the endurance players, 68.6% for the combat players, 64.7% for the skill players, and 72.7 % for the control group. Notably, almost all players were correctly classified on the basis of their physiological and psychological variables.

Table 5: Classification matrix for the sports according to physical, physiological and psychological variables of the discriminant functions

		Classification Results[b,c]					
		Predicted Group Membership					
		Group	Endurance	Combat	Skill	Control	Total
Original	%	Endurance	88.2	8.8	2.9	.0	100.0
		Combat	11.4	74.3	11.4	2.9	100.0
		Skill	.0	11.8	85.3	2.9	100.0
		Control	.0	.0	21.2	78.8	100.0
Cross-validated[a]	%	Endurance	85.3	8.8	5.9	.0	100.0
		Combat	17.1	68.6	11.4	2.9	100.0
		Skill	2.9	14.7	64.7	17.6	100.0
		Control	.0	.0	27.3	72.7	100.0

a. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case. b. 81.6% of original grouped cases correctly classified. c. 72.8% of cross-validated grouped cases correctly classified.

Discussion

The aim of this study was to explore the discriminating power of selected physiological, physical, and psychological variables among 136 Indian male participants of different sports (Endurance=34, Combat=35, Skill games=34), and control group (n=33). Most of the variability among groups was reported by the first discriminant function (65.7%) which reflected variations in physical, physiological, and psychological variables between endurance and other groups of athletes as well as a control group. Endurance players obtained the highest mean value of maximum aerobic capacity (VO2 max among the four groups as is also evident by the demand of the sport. VO2 max is a significant contributor in the model with a structure coefficient of 0.741 in Function 1 and plays an important role in discriminating endurance players from combat and skill players. VO2max is an important variable that sets the upper limit for endurance performance. Endurance training causes an increase in mitochondrial enzyme activities, which improves performance by enhancing fat oxidation and decreasing lactic acid accumulation at a given VO2 (Bassett & Howley, 2000). Upper limits for absolute VO2max have been reported in rowers and cross-country skiers are 7.0–7.5 L·min−1 in males and 5.0−5.5 L·min−1 in females and for relative VO2max in cyclists, runners, and cross-country skiers up to ~90 mL·kg−1·min−1 in males and ~80 mL·kg−1·min−1 in females (Haugen, Paulsen, Seiler, & Sandbakk, 2018), which is quite higher than the values of VO2max obtained for the endurance group in the present study. The mean value of vO-2max for the wrestlers in this study was found to be higher than the results obtained for the U.S. Freestyle Wrestling team (41.2 ml/kg/min) evaluated using a cycle ergometer (Callan et al., 2000) and lower than the values of VO2max (51.9 ± 4.3, n=15) obtained in elite Chilean wrestlers (Venegas-Cárdenas et al., 2019). In a study conducted in Malaysia, the mean value of VO2max obtained in archers (n=12) was 45.1 ± 3.3 ml/kg/min by MSFT (Multi Stage Fitness Test) (Lau, Ghafar, Hashim, & Zulkifli, 2020) which is found to be higher than the value of VO2 max obtained for male elite archers in this study.

The results in Table 1 also revealed that the combat players (wrestlers, judoists) are the heaviest among the four groups, having the highest mean value of body weight, lean body mass, and muscle content. The findings of this study also showed that weight, lean body mass, and muscle content are significant contributors to the discriminant model with a structure coefficient of 0.424, 0.430, and 0.574 in function 2 respectively (Table 3). The results of this study are new insights into the understanding of combat sports like wrestling and judo. Garcia-Pallares, Lopez-Gullon, Bonete, & Izquierdo (2012) have examined the body composition of elite wrestlers and proved that international-level wrestlers had greater fat-free mass (FFM) and less fat tissue. As in all weight-category sports, body weight, and body composition play a major role in judo, and reducing substantial amounts of weight within a short time is a usual part of the competition. It has also been proven that the anaerobic power of judo athletes is influenced by an increase in lean body mass while maintaining the initial level of adipose tissue (Kim et al., 2011).

Skill games like archery and combat sports have completely different characteristics. Greater parasympathetic activity and a balance between both systems of the autonomic nervous system are beneficial to the performance of archers (Lo, Huang, & Hung, 2008). In a comparative study conducted on archers and boxers, it was found that boxers showed sympathetic dominance whereas parasympathetic dominance was found in archers (Aggarwala, Vij, & Dhingra, 2016). In the present study, we have found significant differences in LF/HF ratio ($p<0.05$) between the combat group and remaining three groups (endurance, skill, and control). Different sports activities have different effects on HRV, likely due to different demands of training — such as strength versus endurance, continuous versus interval, and ratio of training to competition. In this study, the highest HRV values were found in cyclists and canoe and kayak paddlers, while the lowest in runners (Merkely et al., 2016).

The general profile of sportsmen in terms of personality is low neuroticism, high extraversion, and conscientiousness, as well as average openness to experience and agreeableness (Anghel, Banica, & Ionescu, 2009). Similar findings were obtained in the present study; however, significant differences were seen only in the personality types of extraversion and neuroticism (Table 2). Anxiety is multidimensional in that it can be divided into different categories, including trait and state anxiety. Trait anxiety is characterized by an inherent inclination to perceive certain stimuli as threatening and in turn to respond with increased state anxiety when a particular stimulus is present. Conversely, state anxiety involves increased levels of physiological arousal, apprehension, fear, and tension. Both trait and state anxiety have cognitive and somatic elements, creating four distinct types of anxiety: cognitive trait anxiety, cognitive state anxiety, somatic trait anxiety, and somatic state anxiety (Cox, 2007). In the case of state anxiety, lowest values were found in athletes involved in endurance sports and the highest in combat sports. Research suggests that elite players exhibit lower state anxiety (Fernandez et al., 2009). Elite competitors, who were defined according to their professional status, interpreted worry symptoms as less debilitative, and somatic anxiety responses as more facilitative than their non-elite counterparts who competed at semi-professional levels or lower (Neil, Mellalieu, & Hanton, 2006). For trait anxiety, no significant differences were seen between the four groups. For future research, it is suggested to involve a greater number of athletes for every discipline to understand the differences in the psychological process to a greater extent.

A study done by Leone et al (2002) revealed that in the discriminant analysis, the anthropometric variables contributed more to the model than the bio-motor variables. This study is in the agreement of the fact that physical and maximal aerobic capacity contributed more than heart rate variability and psychological factors to characterize and distinguish male athletes participating in different sports. There are clear training effects between sports. Success in many different sporting activities would most likely be reliant in part on aerobic power and body composition. In summary, the results showed that after cross validation 72.8% of cases were correctly classified, with 85.3% being correctly classified for the endurance players, 68.6% being correctly classified for the combat players, 64.7% being correctly classified for the skill players and 72.7 % being correctly classified for the control group.

Our study has several limitations. The current sample of athletes was drawn from only one region of the country and therefore generalizability is questionable. Another limitation was the difficulty for the investigators to control for different physiological status and factors that may influence the results of the tests. This study recommends, for wider generalization of results, the replica of the study may be extended to other regions. Coaching as an intervention for non-sports persons should be conducted to see its effects on different variables of physical fitness and adjustment. A third limitation is the focus solely on male athletes. The fourth limitation is that the heart rate variability was measured at rest, not during competition in this study. Therefore, further research on the heart rate variability measurement during exercise using wearable equipment is needed.

Conclusions

In summary, we present a model that could be used to predict the sports of an athlete from a number of physical variables like body weight, lean body mass, and muscle content as well as physiological variable like maximal aerobic capacity. This information might be employed to familiarize the training of athletes towards a specific sport and could also be of use in improving performance in deficit areas. In this work, however, there are also a number of strengths to be highlighted. First, the data provided in this study help to fill some important gaps in the literature providing a better understanding of the physiological characteristics that discriminate athletes into different sports. Second, our findings may have an important impact on the classification system.

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Conflict of Interest
The author declares that there is no conflict of interest.

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