ORIGINAL ARTICLE

Cardiovascular risk in elite Spanish judo athletes

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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Abstract

Background & Study Aim: Cardiovascular diseases are the first cause of death globally and, although athletes have a longer life expectancy, they are not exempt from these diseases. Thus, the aim of this study was the presence of cardiovascular-risk factors in elite judo athletes amongst weight categories.

Material and Methods: Cross-sectional descriptive study in 49 (20 males, 29 females) elite Spanish judo athletes. Cardiovascular risk was assessed through body mass index, body fat percentage, blood pressure, lipid profile, glycaemia, renal and hepatic functions. The athletes were grouped into 3 weight categories and compared using a one-way analysis of variance and Tukey test as post hoc.

Results: Fifty percent of male athletes presented high blood pressure, and stage I hypertension was diagnosed in 30% of cases, while only 17% of females had high blood pressure. Moreover, 45% and 34% of males and females, respectively, showed low HDL-cholesterol levels. Most of the athletes had low body fat percentages; however, 10% of males and 20% of females presented fat excess, and 59% of athletes showed higher body mass than the allowed for their weight category. Fat percentages were higher in heavier categories than in lighter ones ($p<0.001$), and HDL-cholesterol was also significantly impaired in heavier categories for males ($p = 0.015$), but not for females. Nevertheless, uric acid levels of female athletes was higher in heavier categories compared with lighter ones ($p = 0.026$).

Conclusions: The relatively high presence of cardiovascular risk factors suggests the need for monitoring the health status of judo athletes to prevent cardiovascular diseases.

Keywords: blood glucose • blood pressure • body weight • cardiovascular diseases • creatinine • hypertension • lipids • liver function

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Cardiovascular diseases (CVDs) – Is a broad term for a range of diseases affecting the heart and blood vessels, e.g. a heart attack or stroke.

Hypertension – Elevated blood pressure that is diagnosed as a systolic blood pressure at or above 140 mmHg and/or a diastolic blood pressure at or above 90 mmHG. It is a risk factor for CVDs, including ischaemic and haemorrhagic strokes.

Systolic blood pressure – Is the maximum pressure in the arteries when the heart contracts.

Diastolic blood pressure – Is the minimum pressure in the arteries between the heart's contractions.

Lipid profile – Is the levels of lipids (fats) in the blood, abnormal levels are risk factors for CVDs. The most commonly used blood markers are total cholesterol, LDL-cholesterol, HDL-cholesterol and triglycerides.

LDL-cholesterol – Is the low-density lipoprotein cholesterol, elevated values lead to atherosclerosis increasing the risk of heart attack and ischemic stroke.

HDL-cholesterol – Is the high-density lipoprotein cholesterol, it is a preventive factor for CVD since it carries cholesterol away from the blood stream.

Triglyceride – Is the most common type of fat, elevated levels increases the risk for heart attack and stroke by developing atherosclerosis.

AST – Is the aspartate transaminase or aspartate aminotransferase, also known as glutamic oxaloacetic transaminase (GOT). It is commonly measured clinically as a biomarker for liver function.

ALT – Is the alanine transaminase or alanine aminotransferase; a commonly used marker of liver function.

GGT – Is the gamma glutamyltransferase; a biomarker of liver function.

Glycaemia – Is the level of glucose in blood, high level is a risk for future development of CVDs and diabetes.

Introduction

The World Health Organization established that cardiovascular diseases (CVDs) are the first cause of death globally, and they can be prevented by changing risk habits, such as tobacco use, unhealthy diet, physical inactivity and harmful use of alcohol [1]. Current best practice to prevent CVDs involves an early detection of their risk factors, including hypertension, hyperlipidaemias, diabetes, obesity, or impaired renal and hepatic functions [1]. An estimated 17.5 million people died from CVDs in 2012 [1], whereas athletes develop training benefits presenting lower rates of CVDs and living longer than untrained individuals [2]. Therefore, it has been established that regular intense exercise training has protective effects on CVDs and premature death [3, 4]. However, elite athletes are not exempt from CVDs that have been related to sudden cardiac death in the young population (<35 years of age) [5]. In this sense, the prevalence of hypertension in athletes varied from 0% to 83% among different studies, where strength-trained athletes had higher blood pressure than endurance-trained athletes [6]. Furthermore, the lipid profile of some senior and even junior athletes showed altered levels [7, 8]; consequently, assessing cardiovascular risks in athletes from an early age might be necessary to prevent CVDs.

A study with 935 martial arts practitioners [9], indicated that most of them had a body mass index between overweight (karate, Brazilian jiu-jitsu and judo) and normal (kung-fu and taekwondo). When the body mass index of judo practitioners were considered [9], 43.3% were classified as overweight and 12.2% as obese, who also presented a high body fat percentage classified as above average (27.8%) and well above average (16.7%). Although the body composition of elite athletes is frequently characterized by a low body fat mass, weight-categorized sports enable different body compositions at elite level, with higher fat contents in heavier athletes [10]. Hence, combat-sport athletes could show risk-factors differences amongst weight categories [11], with an increased CVDs risk compared with other disciplines.

Furthermore, combat-sport athletes usually undergo rapid weight loss before competitions by dehydration or caloric restriction [12]; thus, periodic anthropometric and haematological assessments are recommended since these athletes can have an impaired health status.

For all these reasons, the aim of this study was the presence of cardiovascular-risk factors in elite judo athletes amongst weight categories.

Material and methods

Design

In this descriptive cross-sectional study, the presence of CVDs risk factors in Spanish elite judo athletes was analysed. The CVDs risk factors were compared among three weight groups in males (group 1: –60kg, –66 kg categories; group 2: –73kg, –81kg, –90 kg categories; group 3: –100kg, +100 kg categories) and females (group 1: –48kg, –52kg kg categories; group 2: –57kg, –63kg, –70 kg categories; group 3: –78kg, +78 kg categories) according to their weight category in competition. The CVDs risk was assessed through the following variables: BMI, body fat percentage, blood pressure, lipid profile, glycaemia, renal and hepatic functions. Blood sampling, blood pressure, and anthropometric assessments were all performed in fasting. The study was carried out in the sport facilities of the High Performance Centre "Joaquín Blume" (Madrid, Spain) during the competitive period.

Participants

The sample consisted of 49 elite athletes from the Spanish National Judo Team (20 males and 29 females) and all weight categories. The participants had an age average of 20.9 ±3.4 years, with a minimum of 17 years and a maximum of 31 years of age. None of the subjects had a history of renal, cardiovascular or hepatic diseases, and none were under medical or psychiatric treatments when participating in the study. This study obtained ethical approval from the Research Ethics Committee of the University of Granada and was in accordance with the Helsinki declaration. After the participants were informed about the procedure and possible risks involved, written informed consent was obtained from all participants or from both parents in cases where the athlete was under 18 years of age.

Procedures

Body composition. BMI was calculated as weight (kg) divided by the square of height (m), its classificatory norms were in accordance with the Spanish Society for Obesity Research (*Sociedad Española para el Estudio de la Obesidad*) [13]. Height was measured to the nearest 0.1 cm using a stadiometer (GPM, Seritex, Inc., Carlstadt, New Jersey). Body mass was measured to the nearest

0.1 kg using a portable scale (model 707, Seca Corporation, Columbia, Maryland. Body fat percentage was estimated through the Carter equation [14]: males' fat% = (Σ6skinfolds· 0.1051) + 2.58, females' fat% = (Σ6skinfolds · 0.1548) + 3.58, where the 6 skinfolds were *triceps*, *subscapular*, *supraspinal*, *abdomen*, *thigh*, and *medial calf* expressed in millimetres). Skinfold thickness was recorded to the nearest 0.2 mm at a constant pressure of 10 g/mm by using a Holtain skinfold caliper (Holtain Ltd., Crymych, UK). Normal ranges of body fat percentages were values between 18-22% in females <21 years old and 21-23% in females ≥21 years old, and values between 15-18% in males <21 years old and 16-20% in males ≥21 years old [15].

Blood pressure. Systolic (SBP) and diastolic (DBP) blood pressures were recorded three times with the athlete seated after they rested 5 minutes, by auscultatory technique using a hybrid sphygmomanometer (Nissei DM-3000). The guidelines of the Hypertension and Cardiology European Societies were used to classify blood pressure stages [16].

Haematological indicators. Lipid profile, blood glucose, creatinine and hepatic function markers were analysed as CVDs risk factors; thus, haematological parameters were classified following current medical consensus, according to age or sex if appropriate. In adults (≥19 years), total cholesterol was considered desirable for <190 mg/dl, borderline high from 190 to 239 mg/dl, or high for values ≥240 mg/dl [17]. In young athletes (<19 years), total cholesterol was desirable for <170 mg/dl, borderline high from 170 to 199 mg/dl, or high for values ≥200 mg/dl [17]. Triglycerides values were classified as desirable, borderline high, and high in adults (≥19 years) for values <150, 150-199, ≥200 mg/dl, respectively; and in young athletes (<19 years) for values <90, 90-129, ≥130 mg/dl, respectively [17]. Low-density lipoprotein cholesterol (LDL-c) was classified as optimal (<70 mg/dl), good (70-99 mg/dl), borderline high (100-114 mg/dl), or high (>114 mg/dl) [18]. High-density lipoprotein cholesterol (HDL-c) was considered desirable if it was >40 mg/dl in males and >45 mg/dl in females [19].

Blood glucose was altered for levels ≥100 mg/dl according to the last consensus [20]. The hepatic function was estimated considering aspartate (AST) and alanine (ALT) aminotransferases (high for values >40 U/l) and gamma-glutamyltransferase (GGT) (high for values >50 U/l) [21]. Uric acid values were classified as desirable (<6.00 mg/dl), borderline high (6.00-8.49 mg/dl), or high (≥8.5 mg/dl) [22]. Creatinine values, as a renal function marker, was high for 1.3 mg/dl in males and 1.1 mg/dl in females [23].

Statistical analysis

Data are presented as mean and standard deviation. The Shapiro-Wilk statistic was used to test the normality of distributions. Differences between the 3 weight-category groups were compared for the same sex only by using a one-way analysis of variance followed by Tukey test for post hoc comparisons. All analyses were conducted using the SPSS statistical package for Windows (version 17.0; SPSS, Inc, Chicago, Illinois, USA), and the level of significance was set at $p<0.05$.

Results

A considerable number of athletes had a higher body mass than the established by their weight categories: 65% of the male athletes (13 of 20 males) and 55% of the female athletes (16 of 29 females) were heavier than the allowed in their respective weight category for competition. The number of athletes with overweight or obesity according to their BMI and body fat percentage is presented in Table 1. The prevalence of high blood pressure levels or hypertension in elite Spanish judo athletes is described in Table 2. The hepatic function markers (AST, ALT, and GGT) showed normal values in all participants, the rest of haematological variables (lipid profile, blood glucose and creatinine) are presented in Table 3 showing the number of athletes with CVDs risk factors. Only 30% of males (6 of 20) and 24% of females (7 of 29) did not presented any risk factor; 45% of males (9 of 20) and 59% of females (17 of 29) presented 1 or 2 risk factors; and 25 of males (5 of 20) and 17% of females (5 of 29) presented 3 or 4 CVDs risk factors. Weight-category comparisons are shown in Table 4 reporting few significant differences in both females and males. These comparisons indicate that heavier athletes had higher body fat percentages than lighter judo athletes. Additionally, male athletes from the heaviest weight category had lower HDL-c levels than those from the lightest weight category.

Discussion

This study highlights that the presence of cardiovascular risk factor in elite Spanish athletes is substantial; thus, their top-level training status seems

Table 1. Prevalence of overweight in elite Spanish judo athletes according to the body mass index and body fat percentage.

Indicator	Variables	Females n = 29	Males n = 20	Total n = 49
Body Mass Index	Insufficient weight (<18.5 kg/m^2)	0	0	0
	Normal weight (18.5-24.9 kg/m^2)	22	11	33
	Overweight degree I (25.0-26.9 kg/m^2)	3	3	6
	Overweight degree II (27.0-29.9 kg/m^2)	3	2	5
	Obesity class I (30.0-34.9 kg/m^2)	1	2	3
	Obesity class II (35.0-39.9 kg/m^2)	0	2	2
Body fat	Insufficient fat	17	18	35
	Normal fat	6	0	6
	Excess of fat	6	2	8

Table 2. Blood pressure of elite Spanish judo athletes.

Indicator	Variables	Femalesn n= 29	Males n = 20	Total n = 49
Systolic blood pressure	Optimal (<120 mmHg)	13	6	19
	Normal (120-129 mmHg)	11	4	15
	High-normal (130-139 mmHg)	5	4	9
	Stage 1 hypertension (140-159 mmHg)	0	6	6
Diastolic blood pressure	Optimal (<80 mmHg)	25	13	38
	Normal (80-84 mmHg)	3	4	7
	High-normal (85-89 mmHg)	1	0	1
	Stage 1 hypertension (90-99 mmHg)	0	3	3

Table 3. Prevalence of cardiovascular risk according to haematological indicators of elite Spanish judo athletes.

Indicator	Variables	Females n = 29	Males n = 20	Total n = 49
Cholesterol	Desirable	24	13	37
	Borderline high	2	6	8
	High	3	1	4
LDL-c	Optimal	25	12	37
	Good	4	6	10
	Borderline high	0	2	2
HDL-c	Desirable	19	11	30
	Low	10	9	19
Triglycerides	Desirable	27	15	42
	Borderline high	1	2	3
	High	1	3	4
Glycaemia	Good	28	19	47
	Altered	1	1	2
Uric acid	Good	12	4	16
	Borderline high	15	15	30
	High	2	1	3
Creatinine	Good	26	20	46
	High	3	0	3

Table 4. Comparisons of cardiovascular risk factors amongst weight categories in elite Spanish judo athletes.

Variables and weight categories (kg)	Females (n = 29)			1w anova P values	Males (n = 20)			1w anova P values
	–48, –52 (n = 8)	–57, –63, –70 (n = 16)	–78, +78 (n = 5)		–60, –66 (n = 6)	–73, –81, –90 (n = 9)	–100, +100 (n = 5)	
BMI (kg/m²)	21.2 ±1.86#	23.2 ±1.61#	28.7 ±2.76	<0.001	22.3 ±1.13*#	25.2 ±1.86#	33.0 ±3.33	<0.001
Body fat (%)	15.1 ±2.75*#	18.9 ±3.25#	28.3 ±5.07	<0.001	7.1 ±1.13#	7.9 ±1.73#	18.0 ±6.38	<0.001
Cholesterol (mg/dl)	161 ±43.33	162 ±24.55	165 ±31.34	0.974	179 ±44.09	170 ±26.50	163 ±47.11	0.171
HDL-c (mg/dl)	54.8 ±15.8	53.0 ±12.11	59.1 ±15.30	0.692	55.9 ±13.74#	46.7 ±7.98	35.5 ±8.68	0.015
LDL-c (mg/dl)	60.1 ±11.86	55.9 ±13.94	55.3 ±18.79	0.769	64.2 ±19.83	70.4 ±17.34	73.3 ±28.53	0.762
Triglycerides (mg/dl)	59.8 ±25.35	71.2 ±25.84	68.1 ±9.45	0.555	83.3 ±47.63	104.9 ±37.07	94.3 ±45.75	0.634
Glycaemia (mg/dl)	74.4 ±12.57	71.1 ±8.75	84.3 ±15.16	0.085	83.0 ±14.75	71.5 ±8.91	84.6 ±7.69	0.065
Uric acid (mg/dl)	7.36 ±1.30	6.81 ±1.26	7.07 ±1.61	0.260	6.97 ±1.31	6.77 ±0.83	6.93 ±1.42	0.937
Creatinine (mg/dl)	0.95 ±0.15	0.93 ±0.14	0.93 ±0.11	0.256	0.90 ±0.21	0.82 ±0.20	0.88 ±0.22	0.738
AST (IU/l)	15.6 ±5.50	17.0 ±7.23	14.7 ±6.13	0.760	19.5 ±3.70	18.0 ±6.50	22.6 ±2.27	0.281
ALT (IU/l)	12.8 ±3.84	11.3 ±3.55	12.1 ±1.10	0.601	17.6 ±4.87	14. 1±3.17	18.3 ±4.57	0.144
GGT (IU/l)	6.7 ±8.46	3.2 ±0.52	3.2 ±0.41	0.172	3.8 ±1.95	8.4 ±15.92	10.2 ±16.04	0.713
Systolic BP (mmHg)	118 ±6.41	112 ±13.41	119 ±8.94	0.372	120 ±8.94	126 ±18.50	133 ±14.83	0.397
Diastolic BP (mmHg)	40 ±1.60	40 ±3.61	40 ±2.19	0.901	45 ±1.67	45± 2.24	43 ±2.07	0.416

AST Aspartate aminotransferase; **ALT**: alanine aminotransferase; **GGT** gamma-glutamyltransferase; **BP** blood pressure
*p<0.005 respect to the middle-weight group (Tukey's post-hoc), #p<0.005 respect to the heavy-weight group.

not enough to achieve good health. Up to 70% of male and 76% of female elite Spanish judo athletes presented at least one CVDs risk factor. Our data showed a high percentage of elite athletes with altered lipid profile; 45% and 34% of male and female athletes, respectively, showed low HDL-cholesterol levels. Moreover, 15% of males presented high triglycerides values, while the number of cases in the rest of lipid profile variables represented less than 10%. A previous study showed an HDL-c decrease in elite athletes after four weeks of judo training [24]; hence, it is possible that this group of athletes should specifically consider this point in order to improve their health, for example, through a fat intake modification [25].

Notwithstanding, Yamaner et al. [26] compared wrestlers and sedentary males, reporting that athletes had higher HDL-c levels, but also higher triglycerides levels; whereas in our study, most of the elite athletes had desirable triglycerides values. Thus, assessing the lipid profile is essential since some athletes can have abnormal values. To sum up, the most impaired lipid profile indicator in elite judo athletes was the HDL-c, while all athletes had desirable or borderline LDL-c values. Triglycerides and total cholesterol values were under health recommendations in most of the cases, although some athletes showed high values. Food habits of elite Spanish judo athletes have been previously analysed [27], showing a high intake of fat and protein; hence, a fat-modified diet could be convenient to improve their lipid profiles [25].

Moreover, a main point of this study is that a considerable number of elite judo athletes showed high blood pressure levels, even presenting hypertension of stage I (30% of male athletes). Accordingly, a previous study established the hypertension as the most prevalent diagnosed disease in athletes [28]; however, it was performed in athletes older than 35 years of age. Thus, the presence of hypertension in our athletes has a special significance due to the fact that our sample is young so they have an increased risk of presenting worse blood pressure levels with aging [29], especially if no preventive actions were taken. The prevalence of hypertension in young adults and adolescents is increasing and, it has been suggested that current hypertension and pre-hypertension diagnosis in the young population could underestimate the longitudinal risk [30]. Therefore, assessing blood pressure is justified in elite athletes even if they are young and, as it is a non-invasive tool, it can be used frequently without affecting performance.

As expected, the BMI overestimated the fat content of judo athletes since they have a high muscle mass [9, 10]. In accordance with this result, the body fat percentage should be a tool for preventing obesity in athletes instead of BMI. Our results showed that most of the athletes had low fat mass; however, 16% of the elite athletes presented an excess of body fat, which is lower than previously reported in judo practitioners [9]. In our study, the athletes competing in heavier weight categories had higher body fat percentages and, as has previously been mentioned, it is important to note the young age of these athletes with overweight (from 17 to 30 years), who could develop CVDs in the future.

On the one hand, overweight and obese people that practice sport can present a good health status, where fitness is a preventing factor for CVDs [31]. On the other hand, the association between overweight and CVDs risk is well documented, and it has been also established in adolescents (17 years old) [32]. Additionally, 59% of the athletes of the present study had a higher body mass than the maximum allowed in their weight categories what suggests weight cycling, an habitual practice in elite judo athletes [12, 33], that induces alterations in haematological indicators of judo athletes [34] and has been related to CVDs even in normal-weight people [35]. Specifically, post-competitive weight gain has been associated with a higher prevalence of CVDs in former athletes [36]. Consequently, some changes in the weight management control of judo athletes should be considered for their current and future health status.

Moreover, CVDs are responsible of the high premature mortality of professional combat sport athletes, such as wrestlers [37]. For all that, assessing CVDs risks in elite judo athletes is necessary for the prevention of health problems. On this basis, research has demonstrated that a complex evaluation of the athlete is the best clinical practice to estimate the long-term risk. Hence, haematological markers of hepatic and renal functions have been also included as CVDs risk factors and they are also used in athletes [38]. The results of the present study showed normal hepatic function in elite judo athletes, as occurred with the glycaemia levels. In addition, AST, ALT and GGT levels showed desirable values without evidence of impaired renal function in these athletes.

Conclusions

Elite Spanish judo athletes showed an altered lipid profile and a considerable prevalence of high blood pressure, generally presenting normal glycaemia, renal and hepatic functions. This significant prevalence of CVDs risk factors, and the presence of heavy athletes with an excess of fat mass, suggest the need for monitoring health status of judo athletes in order to prevent CVDs. In addition, our results suggested weight cycling and rapid weight loss practices, which can be related to the altered lipid profile presented in these athletes.

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