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Sexual dimorphism in anthropometric and fitness measurements of top ju-jitsu contestants

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Key words: Ju-jitsu, high competitive level, sex factor, fat-free mass index, sport-specific fitness, technique

Summary

Introduction. The aim of this study was to establish an anthropometric profile and fitness patterns in elite ju-jitsu athletes.

Material and methods. The study evaluated 25 elite ju-jitsu athletes (13 males and 12 females). The study participants were divided into the two groups: the heavyweight and lightweight athletes, according to sex. During the tests, 6 anthropometric variables and 12 variables and indices from fitness tests were recorded for each subject. Two-way ANOVA was employed for comparison of the means. The statistical significance level was set at $p < 0.05$. Effect size and sexual dimorphism index were also calculated.

Results. There were significant differences in body height and weight between female and male ju-jitsu athletes, with women typically shorter and lighter than men. Male athletes had higher BMI and FFMI compared to women, who had higher FMI. PF% in female athletes was twice higher than in men. Compared to men, female athletes were characterized by significantly longer times of performing *Agility test*, *Evasion actions* and worse on *Flexibility* tests. Male athletes performed better than female subjects in *Handgrip* and *Push-ups* tests. No significant differences were found in other tests between male and female subjects.

Conclusions. 1. Despite significant differences in body build and composition, only a locomotor ability, strength endurance and hand grip test differentiated male from female subjects. 2.These findings might be useful for coaches during individual adaptation of training plans, control over the training process and developing new training methods. A knowledge transfer from karate and judo can also be considered.

Introduction

A ju-jitsu fight is characterized by a great variety of complex technical and tactical actions which can be used by both men and women in vertical and horizontal positions. Division into weight categories helps provide equal chances for the competitors, not only in terms of body weight but also their locomotor abilities, range of punches and kicks (used in the first phase of the fight), strength and leverage after catching the clothes to perform a throw (the second phase of the fight) and using immobilization, choke and joint manipulation techniques during groundwork (in the third phase of the fight). A popular tendency before tournaments is body mass reduction that affects body composition. The athletes usually aim at increasing the percentage of fat-free mass in overall body mass in order to improve relative strength when competing in a particular weight category [1]. The fight is characterized by increased activity in both attack and defence, which represent a high-intensity exercise. Duration of these intermittent efforts largely depends on the effectiveness of technical and tactical actions in individual phases of the fight. Fighting according to the regulations for sport ju-jitsu is a combination of the skills typical of karate and judo competition [2,3]. Therefore, it was adopted that special fitness tests developed for karate (SPFT) and judo (SJFT), although having its individual specificity, might be used in ju-jitsu [4].

Conception of study. It was assumed that a sport ju-jitsu fight makes similar demands on both women and men [5]. Division into weight categories in both genders provides equal chances for all the competitors. We propose a hypothesis that women differ more in body build and composition than men rather than in quality of performing specific fitness tests which contain technical skills typical of the judo fight.

The aim of this study is to compare anthropometric data, body composition and sport-specific fitness of male and female subjects, and to establish an anthropometric profile and fitness patterns of elite ju-jitsu athletes.

Material and methods

Subjects

The project was approved by the Bioethical Committee at the Regional Medical Chamber (Polish: *Regionalna Izba Lekarska*) in Cracow, Poland, No. 35/KBL/OIL/2011). The subjects and their coaches were familiarized with the methodology of the fitness tests, expressed their consent to perform intensive physical exercise and were interested in the results obtained. The study evaluated 13 elite male ju-jitsu athletes (group M). General results of top level female ju-jitsu athletes (group F, n=12) previously analysed according to age factor only were used for comparison purposes. The first author and the publisher of the original publication gave permission for reproduction the descriptive data of female ju-jitsu athletes [6]. A standardized sports interview was carried out. It contained date of birth, training experience, weekly number of training sessions and their duration, competitive weight category, preferred fighting technique out of nine classification groups (punches, kicks, hand throws, leg throws, hip throws, sacrifice throws, chokes, levers, hold techniques) and sports achievements. Both groups M and F were evaluated during their competitive period. Subjects mean age was 21.6±5.4 years, mean training experience was 8.9±6.7 years and they practised during 3 to 8 training sessions per week (4.5h to 16.0h). Ten subjects in both groups had international competitive level (I) while 3 and 2 people had national competitive level (N) in groups M and F, respectively. The most of the people (16 / 25) were included in older categories (≥19 years), whereas other subjects (9 / 25) were classified under younger categories (17-18 years). Frequency distribution in younger and older categories did not depend on sex factor (Chi-Square with Yates' correction = 0.968, df =1, p = 0.325) (Table 1). Frequency distribution in male weight categories (M: heavier H – 84 kg, - 94 kg, +94 kg; lighter L – 55 kg, 62 kg, 69 kg, 74 kg, 77 kg, -79 kg) and female weight categories (F: heavier H – 62 kg, -70 kg, +70 kg; lighter L – up to 55 kg) did not differ significantly (Chi-Square= 0.037, p = 0.848) (Table 2).

Measurements

Basic measurements were taken and anthropometric indices were computed: body height (m) (Martin's anthropometer, USA), body mass (kg), BMI (kg/m^2) and body composition: fat-free mass (kg) and fat mass (kg) (scale model TBF 300, Tanita Co., Tokyo, Japan). This was the basis for computation of fat-free mass index (FFMI) and fat mass index (FMI) in kg/m^2 [7]. After a routine warm-up according to the instructions [8,9], physical fitness measurements were carried out by means of ***SPFT*** battery: *Hip turning (s), Punching speed (s) Flexibility (cm), Flexibility index (cm/cm), Rapid kicks (s), Agility (s), Evasive actions (s), Push-ups (reps); handgrip test* ***HGS:*** *HGS (kgf), HGS (kgf/kg)* and ***SJFT:*** *Total throws, Index.* In sport ju-jitsu, these tests have been already performed in a group of coaches [4] and a female national team [6].

Statistics

Two-way ANOVA (Sex factor; Weight category factor) was employed for comparison of the means. Differences between groups were tested with multiple range Tukey test. The designated level of statistical significance was set at $p<0.05$. Effect size expressed as eta-squared (η^2) and the two-step ratio index of sexual dimorphism (SDI) was also computed [10,11]: (1) if M ≥ F, SDI = M/F; (2) if F ≥ M, SDI = 2-F/M, where M and F are means for male and female athletes, respectively. Pearson correlation coefficient was counted between anthropologic and fitness data. Next, the structure of physical fitness were described using Cluster analysis (furthest neighbor method, city block distance – complete linkage). Statgraphics Centurion 16.2 software was employed.

Results

The results obtained in the study are presented in Table 3. In the 9 classification groups of ju-jitsu techniques, men and women used techniques from 2 to 7 and 2 to 6 groups, respectively. The number of preferred techniques did not depend on the factors of Sex or Weight category.

Effect of Sex factor on body build and fitness

The effect of Sex factor was significant (p = 0.000) in the case of body height (Males = 1.77 m vs. Females = 1.65 m, F = 26.72, η^2 = 0.48, SDI = 1.07) and body mass (Males = 79.48 kg vs. Females = 58.69 kg, F = 38.56, η^2 = 0.44, SDI = 1.35). Women were characterized by significantly lower BMI (21.5 kg/m^2 vs. 25.1 kg/m^2, F = 23.36, η^2 = 0.32, SDI = 1.17), FFMI (16.5 kg/m^2 vs. 22.2 kg/m^2, F = 131.92, η^2 = 0.81, SDI = 1.35) whereas they had higher FMI (4.9 vs. 2.9 kg/m^2, F = 22.36, η^2 = 0.29, SDI = 0.31). Fat percentage in women was twice higher than in men (22.5% vs. 11.0%, F = 64.3, η^2 = 0.58, SDI = -0.05.

Table 1. Frequency table for Sex by Age Category of 25 top Polish ju-jitsu athletes

Groups	Older ≥ 19 years	Younger ≤ 18 years	Total
Male	10	3	13
Female	6	6	12
Total	16	9	25

Table 2. Sample size for sex and weight categories of 25 top Polish ju-jitsu athletes

Groups	Heavier	Lighter	Total
Male	6	7	13
Female	6	6	12
Total	12	13	25

Table 3. Body build, body composition and special fitness characteristics of male and female ju-jitsu contestants. Values are mean and SE

Variable	Female (n=12)				Male (n=13)			
	Heavy FH (n=6)		Light FL (n=6)		Heavy MH (n=6)		Light ML (n=7)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Anthropometric								
Body mass (kg)	65.67	3.41^{bc}	51.72	3.41^{acd}	90.33	3.41^{abd}	68.63	3.16^{bc}
Height (m)	1.68	0.02^{c}	1.61	0.02^{cd}	1.81	0.02^{ab}	1.73	0.02^{b}
BMI (kg/m^2)	23.18	0.77^{bc}	19.73	0.77^{acd}	27.38	0.77^{abd}	22.82	0.71^{bc}
FFMI (kg/m^{-2})	17.27	0.50^{cd}	15.81	0.50^{cd}	23.20	0.50^{abd}	21.19	0.46^{abc}
FMI (kg/m^{-2})	5.90	0.43^{bcd}	3.91	0.43^{ad}	4.17	0.43^{ad}	1.64	0.40^{abc}
PF%	25.42	1.46^{bcd}	19.63	1.46^{ad}	14.87	1.46^{ad}	7.14	1.35^{abc}
SPFT								
Hip turning (s)	10.23	1.23	12.35	1.23	12.10	1.23	12.67	1.14
Punching speed (s)	10.12	1.01	11.52	1.01	11.65	1.01	10.67	0.93
Flexibility (cm)	173.3	3.67	160	3.67^{c}	180.0	3.67^{b}	171.4	3.40
Flexibility index (cm/cm)	1.03	0.02	0.99	0.02	0.99	0.02	0.99	0.02
Rapid kicks (s)	19.93	0.83	18.63	0.83	19.98	0.83	17.87	0.76
Agility (s)	17.55	0.56	18.23	0.56^{d}	15.95	0.56	15.84	0.54^{b}
Evasive actions (s)	46.27	1.46^{c}	44.35	1.46	38.93	1.46^{a}	43.78	1.35
Push-ups (reps)	25.33	2.53^{d}	28.17	2.53^{d}	34.00	2.53	40.71	2.34^{ab}
HGS								
HGS (kgf)	39.17	2.49^{cd}	36.33	2.49^{cd}	65.00	2.49^{ab}	56.29	2.30^{ab}
HGS (kgf/kg)	0.60	0.03^{d}	0.70	0.03^{d}	0.72	0.03	0.82	0.03^{ab}
SJFT								
Total Throws	24.8	1.12	25.5	1.12	25.2	1.12	25.7	1.12
Index	12.9	0.93	14.8	0.93	14.3	0.93	13.4	0.93
Technical								
Technique variation (n)	4.5	0.6	3.8	0.6	3.8	0.6	3.6	0.6

a – different from FH, b – different from FL, c – different from MH, d – different from ML.

The substantial effect of Sex factor was manifested in better results obtained by the men compared to women in *Flexibility* test *(*Males = 175.7 cm vs. Females = 166.7 cm, F = 6.29, p = 0.020, η^2 = 0,17, SDI = 1.05), but not in *Flexibility index* (F = 0.88, p = 0.358, η^2 = 0.04). Men performed better than women in *Agility* test (Males = 15.90s vs. 17.89s, F = 12.30, p = 0.002, η^2 = 0.36, SDI = 0.87), *Evasive action* test (Males = 41.35s vs. Females = 45.3s, F = 7.59, p = 0.012, η^2 = 0.22, SDI = 0.90), *HGS* in kgf (60.6 kgf vs. 37.8 kgf, F = 87.84, p = 0.000, η^2 = 0.77, SDI = 1.59), *HGS* in kgf/kg (0.77 kgf/ kg vs. 0.65 kgf/kg, F = 15.53, p=0.000, η^2 = 0.31, SDI = 1.18) and *Push-ups* test (Males = 37.8 repetitions. vs. Females = 26.8 reps., F = 18.12, p = 1.41, η^2 = 0,41, SDI = 1.41). No significant differences were found in *Hip turning*, *Punching speed*, *Rapid kicks* and in *SJFT* (*Total throws* and *Index*).

Effect of weight category factor on body build and fitness

The factor of weight category had significant effect on the characteristics and indices of body build and body composition of the athletes. The subjects from the lighter category were shorter (1.67 m vs. 1.74 m, F = 9.76, p = 0.005, η^2 = 0.17) and had lower body mass (60.17 kg vs. 78.00 kg, F = 28.35, p = 0.000, η^2 = 0.33) and BMI (21.3 kg/m^2 vs. 25.3 kg/m^2, F = 28.09, η^2 = 0.39) compared to those from the heavier weight category. Furthermore, heavyweight category athletes were characterized by significantly higher level of FFMI than the athletes from the lightweight category (20.2 kg/m^2 vs. 18.5 kg/m^2, F = 18.79, η^2 = 0.08), FMI (5.0 kg/m^2 vs. 2.8 kg/m^2, F = 28.55, p = 0.000, η^2 = 0.38) and PF% (20.1% vs. 13.4%, F = 22.10, p = 0.000, η^2 = 0.17).

The effect of weight category factor on the results obtained in ju-jitsu-specific tests was insignificant (p > 0.05), except for *Flexibility* (F = 9.21, p = 0.006, η^2 = 0.25), with heavyweights having better results (176.7 cm) than lightweights (165.7 cm). But when the results from *Flexibility* test are expressed in relation to body height, the significant difference no longer exists. An interaction of Sex*Weight category was revealed in *Evasion actions* (F = 5.55, p = 0.028, η^2 = 0.16), where the FH group had significantly longer performance time than MH group. A significant difference was found in *HGS* (H = 52.08 kgf vs. L = 47.1 kgf, F = 5.59, η^2 = 0.05). There was an opposite direction of differences in *HGS* expressed in relation to body mass (Heavyweights = 0.66 kgf/kg vs. Lightweights = 0.76 kgf/kg, F = 10.89, p = 0.003, η^2 =0.22).

Correlations between body build and sport-specific test results

Body height correlated significantly with the results obtained in the tests *Evasion actions* (-0.72, p < 0.01), *HGS* rel to BM (-0.68, p < 0,01) and *Push-ups* (-0.56, p < 0.05) in males. Similar correlations were demonstrated between body mass and results obtained for *Evasion actions* (-0.62, p < 0.05) and *HGS* rel to BM (-0.58, p < 0.05). Values of BMI and FFMI correlated with *HGS rel* to BM (-0.56, p < 0.05 and -0.63, p < 0.01). FMI and PF% affected the quality of performing *Punching speed* test (0.62, p < 0.05 and 0.72, p < 0.01), while

percent fat correlated with the number of *Push-ups* (-0.59, $p < 0.05$) and *Index in SJFT* (0.57, $p < 0.05$). A correlation of both Height and Body mass and *HGS* rel to BM (-0.64, $p < 0.01$ and -0.58, $p < 0.05$) was found in women. Higher BMI, FMI and PF% were correlated with higher level of flexibility index (0.58, 0.61, 0.65, $p<0.05$).

Comparison of the structure of special fitness between top male and female ju-jitsu practitioners

Figure 1 presents dendrogram of variables grouped in three clusters of special ju-jitsu fitness for male and female competitors at the top sport skill level.

The results of special ju-jitsu fitness tests obtained for males are grouped in three clusters in the dendrogram. The left part of the diagram contains the results obtained in *Agility, Rapid kicks*, and *Flexibility* tests. These tests are performed while standing on one foot. Furthermore, the roundhouse kick '*Mawashi-geri'* is a technique repeated both in *Flexibility* and *Rapid kicks* tests. The central part of the diagram groups the results of tests that provide information on strength endurance (*Push-ups, Evasion actions*), relative hand grip strength (*HGS rel)* and *SJFT (Total throws). Hip turning* is a component of a series of punches in *Punching speed* test, thus they were connected in the Cluster on the right of the diagram.

For comparison purposes, the results of special ju-jitsu fitness tests obtained for women were added to same diagram (Fig. 1). The cluster on the left side of the diagram contains the results of *Punching speed* and *Agility tests.* During the fight, performance of *punches* needs good assessment of the distance to the moving opponent. In *Agility test*, it is critical to use good spatial orientation and change directions properly according to a zigzag route. This cluster includes *Flexibility* test performed while standing on one leg (similarly as in the *Agility* test). The central part contains logically connected movements useful in both attack and defence. The first part of this cluster contains the results of *Rapid kicks* and *Evasion actions* tests and the next one includes *Hip turning speed* test. *Hip turning* is necessary for good performance of *Mawashi geri* (roundhouse kick used in *Rapid kicks* test) and is very useful for absorbing impact of a fist or foot aimed at *solar plexus,* which is one of vulnerable points. On right side of the dendrogram, performance in *Push-ups* (very important skill during fighting in a clinch) and *Total throws* are clustered. Both above mentioned tests necessitate muscle endurance and good neuromuscular coordination because they restrain eccentric and concentric explosive actions which are based on flexibility of the stretched muscles. These actions were repeated in the longest time-consuming tests, which also need endurance. This group is connected with *HGS* relative to body mass. This seems to be justified because it is impossible to throw an opponent without a strong grip. The typical actions in the first phase of a fight are grouped in the central and left Clusters, whereas actions typical of the second phase are grouped in the cluster on the right.

Discussion

The main findings of this paper are the effect of factors of Sex and Weight category on the anthropometric and ju-jitsu-specific fitness variables: 1. Both Sex and Weight category factors affected characteristics of body build and body composition of top level ju-jitsu competitors. 2. Both Sex and Weight factors affected the performance level in sport-specific test in top ju-jitsu competitors. 3. There are some differen-

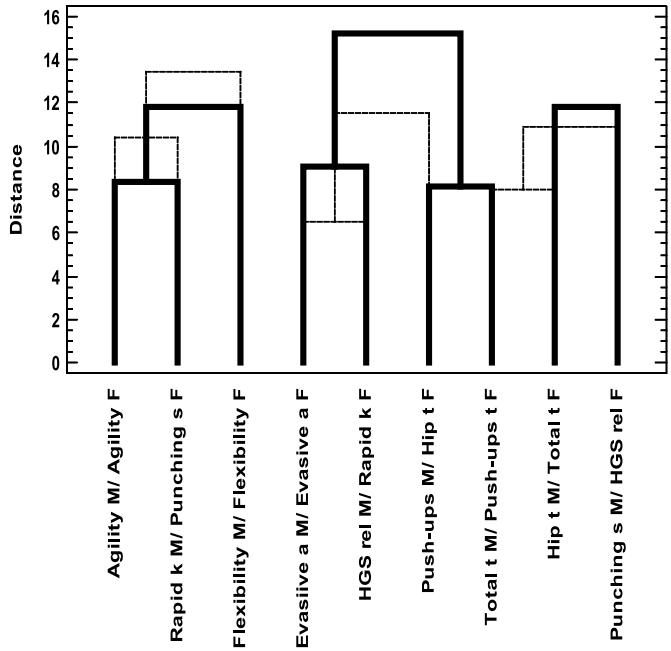

Fig. 1. Dendrogram of fitness structure in males – a solid line and females – a broken line top level ju-jitsu athletes

ces and similarities in the profile and structure of special fitness in male and female ju-jitsu competitors.

Fat-free mass index in male athletes (M) was significantly higher than that of female subjects (F), while fat mass index and percentage of fat in group M were significantly lower than in group F. There were no significant differences in this study between weight categories in body height in groups M and F. Characteristic differences in body mass, BMI and FMI were found between weight categories in the male group. In women, the exception was FFMI (insignificant difference). An interesting contrast was observed between groups ML and FH, which were similar in terms of body height, body mass and BMI, where significant intergroup differences suggested higher values of FFMI in group ML compared to group FH (by 22.7%) whereas FMI and PF% were significantly lower in ML compared to FH (by 259% and 256%, respectively). Sexual dimorphism index in the whole group ranged from -0.05 in PF% to 1.35 in FFMI. These findings confirm a typical sexual dimorphism in body size and proportionality reported previously in the studies on fencing [12], karate [13,14], taekwondo [12,15,] and judo top level competitors [12,16]. Only one paper compared body build in male and female ju-jitsu practitioners [17]. Results of the tests carried out among the members of Polish national team [this study] and German national team [17] are consistent in terms of age (21.6 years vs. 22.3 years), training experience (8.9 years vs. 8.9 years) and weekly number of training sessions (8.7 h/week vs. 6.2 h/week). Male Polish national team was characterized by lower percentage fat in body mass compared to the German team (10.7% vs. 17.4%), while PF in the female groups was similar (22.5% vs. 23.6%).

Observations made in similar / combat sports suggest the choice of the fighting technique to body build of competitors at previous stage of training. High FFMI and mesomorphy components was typical of those top level karate competitors who preferred hand techniques rather than kicks [18]. This body build in judo also caused preference for hand throws during the fight [19]. *Seoi-nage* is typical hand technique [20] in which the Physical lever is applied with variable arm [21]. The advantage of athletes with high BMI and FFMI over the competitors in their weight categories is caused by a deeper and firmer location of the center of mass during an attempt to throw an opponent. Shorter limbs might make it easier for a competitor to perform joint locks and strangulation/choking [17]. No effect of Sex and Weight category factors on the number of preferred techniques from 9 classification groups was found in this study. Previous findings have demonstrated that body composition and somatotype differentiated between ju-jitsu athletes within weight categories. The males of higher sport skill level practised more varied attacks which help get advantage over the opponent. Body composition and somatotype can affect the choice of attack techniques preferred during a fight and determine performance level [22].

To our knowledge, no comparative studies on motor abilities in male and female ju-jitsu competitors have been carried out so far. Significant differences between groups M and F pointed to better performance of men in *Agility*, *Evasive actions*, *Push-ups* and *Hand grip* tests. Both *Agility* and *Evasive actions* are very important in the first phase of fighting and represent locomotor performance without grip (open kinematic chain). Group ML had significantly shorter time (better score) in performing *Agilit*y test over group FL (by 15.1%), whereas in *Evasive actions*, group MH dominated over group FH (with the difference of 18.9%). In *Push-ups* test, which represents local muscle strength endurance, group ML dominated over FL (44.5%) and FH (60.7%) groups, but insignificantly over the group MH (19.7%).

Sex and Weight category factors affect body build and body composition of ju-jitsu athletes. Therefore, the correlations between them and fitness tests battery were computed separately for males and females. In males, a negative effect of body height on performance in the tests that require strength (*HGS* rel to BM) and strength endurance (*Evasion actions, Push-ups*) was found. Furthermore, higher body mass in this group was correlated with worse results obtained in *Evasion actions* and *HGS* relative to BM. Higher BMI and FFMI were correlated with lower values of *HGS* relative to BM. Increased body fat (FMI and PF%) was correlated with longer time of performing *Punching speed* test (worse results). Higher fat percentage also deteriorated the quality of performance of *Push-ups* test (fewer repetitions). Increased content of fat in whole body mass (PF%) correlated with higher *Index*-value in *SJFT* = (HRdirectly after last throw + HRafter 1 minute recovery) / Total throws. Fewer correlations in women between body build traits and sport-specific test results confirmed only a negative dependence of *HGS* relative to BM on body height (moderate correlation), which was demonstrated in the men's group (strong correlation). Moderate correlations between *Flexibility index* and BMI, FMI and PF% are difficult to be explained. However, these correlations might be only apparent since FMI and FFMI are the components of BMI. Computation of partial correlation between FMI and *Flexibility index* with exclusion of FFMI showed that this significant relationship no longer exists.

Some authors argued that an indicator of speed endurance is maximum number of hand techniques and leg techniques performed in 20s and 25s, respectively. Furthermore, an indicator of strength endurance was a maximum number of the same techniques performed in 40s and 45s, respectively [20,23]. We described above mentioned the structure of special fitness in ju-jitsu athletes using Cluster analysis (Fig. 1). Time of performance of *Agility* (15.89s) and *Rapid kicks* (18.42s) tests among men might suggest good speed endurance of the athletes. The results of fitness tests grouped in the central part of the dendrogram provide information about strength endurance of lower limb muscles (in *Evasion actions,* with mean duration of 41.35 s), chest muscles and upper limb muscles (in *Push-ups,* at n = 37.4, the expected duration of the effort for this number of repetitions is ca. 37s). The results obtained for the relative hand grip test (*HGS* in relation to body mass was 0.77 kgf/kg) also seem to be critical to the general picture of the fitness since a strong grip is critical in performing throws in *SJFT* test (which included 3 efforts: 15s, 30s, 30s, with two rests of 10s, which makes 95s in total). *Hip*

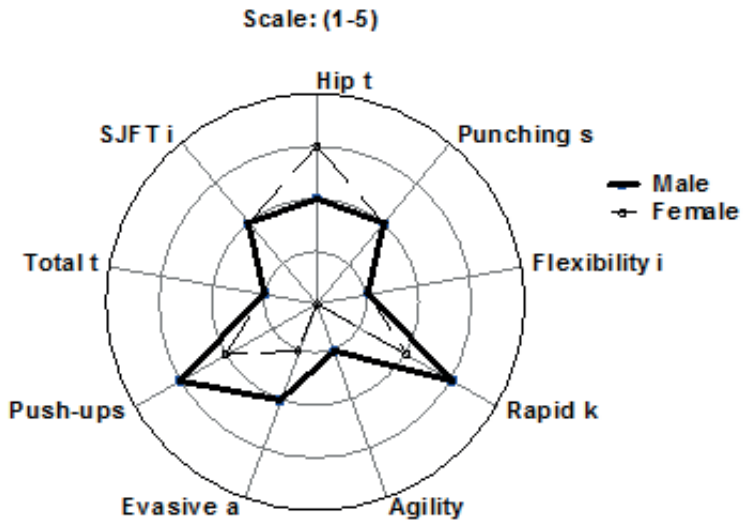

Fig. 2. Male and female profiles of top level competitors in special ju-jitsu fitness tests. 1 – Very poor mark is located in the centre; 5 – excellent could be marked on the external circle

turning and *Punching speed* tests constitute Cluster on the right side of the diagram. These are test exercises of speed character as they take only 11.16s and 12.39s, respectively. In this context, comparison of special fitness structure revealed by the descriptive method of cluster analysis in male and female ju-jitsu athletes leads to interesting conclusions. In both male and female characteristics, the cluster on the left side of the diagram includes *Agility* and *Flexibility,* and, additionally, *Rapid kicks* (in men) and *Punching speed* (in women), which represent the frequency of kicks and punches with fists. The joint component of the central Cluster is *Evasive action* test. The results obtained in *Evasive actions* test are related to the results of testing strength (*HGS* relative to BM), strength endurance of upper limbs (*Push-ups*) and the number of one-shoulder throws performed in *SJFT.* In women, this group also contains the results of shorter duration tests, which, similar to *Evasive actions*, engage mainly lower limbs (*Rapid kicks* and *Hip turning* with similar movement patterns). The right side of the diagram contains the results obtained from short-duration tests in men (with similar movement pattern), whereas the structure of special fitness of women in this region contains the group of tests that provide information about relative strength (*HGS* relative to BM), strength endurance of upper limbs (*Push-ups*) and the number of one-shoulder throws performed during *SJFT.* It is remarkable that the content of this Cluster in women is very similar to the central Cluster typical of men.

Finally, Fig. 2 illustrates a comparison of special fitness test results with normative data obtained for karatekas [8]and judokas [9]. Men from ju-jitsu national team were evaluated at the highest level for performing *Rapid kicks* (4) and *Push-ups* (4) tests, whereas they obtained the worst results during performance of *Flexibility index, Agility* and *Total throws* (2). In female national team, the best results were recorded in *Hip turning speed* test (4), whereas the worst results were obtained during *Agility* test (1). Group profiles did not score the 'excellent' note (5). In discussion, we realize that the normative values determined for karatekas and judokas are high [8, 9]. This happens because specific training of these athletes focuses on the use of punches and kicks (karate) or throws (judo) and grappling in horizontal position (judo). Ju-jitsu makes greater demands on the fighting technique [5]. The majority of ju-jitsu coaches agree that this sport should be practised by ca. 5 years in order to obtain a black belt. The most important factor in achievement of a champion level is technical and tactical preparation. A substantial role is also played by physical fitness while the less important factors are psychological and theoretical preparation. [3,24]. Our study concerns physical preparation, which we evaluated in the aspect of special fitness. The next stage of our investigations will focus on obtaining profiles typical of athletes with lower level of achievements in sport ju-jitsu in order to compare them with the anthropometric profile and fitness patterns obtained for elite ju-jitsu athletes obtained in this paper.

Conclusions

1. The anthropometric profiles and fitness patterns of elite ju-jitsu athletes were established.
2. Despite significant differences in body build and composition, only a locomotor ability, strength endurance and hand grip test differentiated males from females.
3. These findings might be useful for coaches during individual adaptation of training plans, control over the training process and developing new training methods. A knowledge transfer from karate and judo can also be considered.

Practical applications

With regard to the specific requirements of ju-jitsu fighting (fighting in vertical and horizontal position that takes 3 min-

utes with an extra time of 2 minutes in the case of a draw [5]), we are convinced that, with all its complexity, this new sport is very similar to karate and judo. While striving for achievement of a balance between training and competition, continuous updating of a comprehensive characterization of ju-jitsu fighting seems to be necessary [2,3]. This will help modify training methods and verify training effects. After exclusion of individual profiles, one can separate strengths and weaknesses of fitness preparation of ju-jitsu athletes [4]. Improvement in special fitness, which is useful at individual phases of the fight, depends on careful transfer of training methodologies and forms which have been already used in similar sports [3,25-29].

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