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Is the level of static strength and strength endurance a reflection of morphological differentiation among judo and ju-jitsu athletes?

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Jadwiga Pietraszewska[1ABCD], Anna Burdukiewicz[1ABCDE], Aleksandra Stachoń[1BCD], Kazimierz Witkowski[3BD], Justyna Andrzejewska[1BD], Tadeusz Stefaniak[2AB], Krystyna Chromik[1BD], Dariusz Harmaciński[2B], Jarosław Maśliński[3B]

[1] Department of Physical Anthropology, University School of Physical Education, Wrocław, Poland
[2] Department of Individual Sports, University School of Physical Education, Wrocław, Poland
[3] Department of Martial Arts, University School of Physical Education, Wrocław, Poland

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Abstract

Background & Study Aim: Close resemblance of starting activity relates to judo and ju-jitsu athletes divided into several weight categories. Any changes in weight category or lowering body mass before competitions are a common practice.

The purpose of this study was to answer the question whether the level of static strength and strength endurance reflects morphological differentiation among judo and ju-jitsu athletes.

Material & methods: The study involved 74 competitors training combat sports (judo n = 30; ju-jitsu n = 44) aged 19-26 years old. Training experience amounted from 5 to 12 years. Athletes represented weight categories from 66 to 100 kg. Several anthropometric measurements were performed. BMI index was used in the study. Somatic build was assessed according to the Sheldon's method as modified by Heath and Carter. It was determined to which of the three following body build types: endomorph, ectomorph, mesomorph the participants belong. Tissue composition was determined with the use of BIA 101 impedance analyzer operating on Bodygram software. Handgrip strength, back muscles strength were measured and the following motor tests were performed: bent arm hang, standing broad jump, sit-up test.

Results: The first set I (n = 51) is a group of athletes with significantly lower level of handgrip strength and back muscle strength, and higher strength endurance (measured with the duration of hang on the bar and the number of sit-ups). Representatives of the second set II (n = 23) can be characterized by the type of motor performance based on higher static strength, lower endurance strength measured with the duration of hang on the bar and the number of sit-ups. All participants are mesomorphs, however the distribution of mesomorphic and ectomorphic components significantly differs in both groups. In set I the somatotype can be depicted with the following formula: 2.1-5.8-2.1, whereas in set II: 2.2-7.1-1.3.

Conclusions: The results suggest the necessity for combat sports athletes (judo, ju-jitsu) to adjust suitable fight techniques during offensive and defensive actions according to their somatic predispositions.

Keywords: combat sports · anthropometric measurements · body composition · motor tests

Address for correspondence: Jadwiga Pietraszewska, Department of Physical Anthropology, University School of Physical Education in Wrocław, Al. Paderewskiego 35, 51-612 Wrocław, Poland; e-mail: jadwiga.pietraszewska@awf.wroc.pl

Waza – a technique or movement which is based on a standard form and is used to challenge and defeat the opponent [24]

INTRODUCTION

In combat sports competitors use various methods and fighting techniques, such as throwing (*nage waza*), spinning (*katame waza*), strangling (*shime waza*), grappling (*kansetsu waza*), striking (with arms or arms and legs). Combat sport athletes should characterize with special flexibility, agility, quickness, coordination and balance [1]. Appropriate development of arm, back, legs and abdomen muscles play a significant role and that guarantees optimal effectiveness of motor actions during a fight [2]). Moreover, authors of such recommendations point out that strength endurance is as important as maximal strength. This motor ability is essential to maintain correct body posture before performing certain throwing or striking technique. Studies have shown that in such sports as judo and ju-jitsu a competitor holds an opponent by judogi (clothing) for a long time. A substantial handgrip strength is crucial in fight circumstances [3, 4].

Close contact with an opponent means that frequently there is not enough space to perform dynamic offensive or defensive movement activities. Therefore, enhancing isometric strength of upper body part constitutes a crucial part of training for combat sports athletes. On the other hand, competitors must permanently adapt to constant change in conditions and react to opponent actions both during an attack and defence [5]. A martial arts athlete must therefore fulfil high functional requirements, that guarantee appropriate speed and accuracy of particular techniques performed during a fight [5].

The effectiveness of particular fight technique also depends on the development level of some somatic features [6, 7]. Research results reveal that various components of motor performance are diversely related to morphological features [8]. Knowledge on this relations allows to distinguish some somatic criteria for particular combat sports, which to some extent may determine success of the best athletes [5, 9].

Natural factor that differentiates the entire group of combat sport athletes involves various weight categories and, consequently, morphological resemblance of the elite of various categories [10, 11]. Numerous scientists point to the predominance of mesomorphs in their somatotype [12-16]. Moreover, it was found that the development level of body build components and some other elements vary depending on the sporting performance, weight categories and fighting technique preferred by given competitor [6, 13, 16, 17].

The purpose of this study was to answer the: whether the level of static strength and strength endurance reflects morphological differentiation among judo and ju-jitsu athletes.

MATERIAL AND METHODS

Participans

The study involved 74 competitors training combat sports (judo n = 30; ju-jitsu n = 44) aged 19-26 years old. Training experience amounted from 5 to 12 years. Athletes represented weight categories from 66 to 100 kg.

The project was approved by the Bioethics Committee of the University School of Physical Education in Wrocław.

PROCEDURES

Anthropometric measurements

The following parameters were measured using anthropometer produced by GPM Anthropological Instruments: body height (B-v), length of lower limbs (B-tro), sitting height (B-vs), upper extremity length (a-da3), arm span (da3-da3). Width measurements were performed using clevis compass produced by the spreading caliper. The following trunk chords were measured: width (thl-thl) and depth (xi-ths) of a chest, shoulder width (a-a), hips' width (ic-ic) and the width of the shoulder girdle on deltoideum (dl-dl), bitrochanteric width (tro-tro). Additionally, the following widths of epiphyses were measured: elbow width (cl-cm), interstyloid width (spr-spu) and knee width (epl-epm). The following body circumferences were determined: neck, shoulder girdle, waist, arm with muscles tensed and untensed, maximal circumference of forearm, hips, thigh and calf. Skinfolds (under scapula, over the triceps, over the iliac crest, on the abdomen, on the calf) were measured using Harpenden skinfold callipers. Body weight was measured with the use of electronic scale.

BMI index was used to assess the relationship between weight and height. Somatic build was evaluated with the use of Sheldon's method as modified by Heath and Carter. It was determined to which of the three following body build types, i.e. endomorph, ectomorph, mesomorph, the participants belong. Tissue composition was determined with the use of BIA 101 impedance analyzer operating on Bodygram software. The analysis includes body fat content, lean body mass and water content.

Evaluation of physical fitness

Strength potential was assessed using dynamometric measurements. Handgrip strength was measured using hand dynamometer produced by Takei having measuring range of 0-100kG and accuracy 0.5 kG. A grip of dynamometer can be regulated. Back muscle strength was measured with Takei back and leg muscle dynamometer having measuring range of 0-250 kG and accuracy 0.5 kG. Additionally, the following motor tests were performed: bent arm hang, standing broad jump, sit-up test.

Statistical analysis

The statistics was based on cluster analysis (using k-means method). Grouping variables included handgrip strength, back muscle strength and hang duration. Two concentrations were determined that most strongly differed from each other as regards of the results of motor tests. First set comprised 51 people, whereas the second 23. In both groups the distribution of analyzed variables were studied using the Kolmogorov-Smirnov test. No significant deviations from normal distribution were determined. Therefore, subsequent methods were selected based on the assumption of normal distribution. Differentiation between groups was determined using Students' t-test.

RESULTS

The first set I (n = 51) is a group of athletes with significantly lower level of handgrip strength and back muscle strength, and higher strength endurance (measured with the duration of hang on the bar and the number of sit-ups). Representatives of the second set II (n = 23) can be characterized by the type of motor performance based on higher static strength, lower endurance strength measured with the duration of hang on the bar and the number of the number of sit-ups (Table 1). The length of standing broad jump does not differentiate both groups of combat sports athletes in statistically significant manner (Tables 1-4).

Table 1. Statistical characteristics of the length/height, breadth measurements and body mass

Variable	I group (n = 51)		II group (n = 23)		Student`s t-test [p]
	Mean	SD	Mean	SD	
Body mass [kg]	77.3	9.45	88.5	13.36	0.000
Body height [cm]	178.1	7.42	180.1	6.86	0.280
Upper extremity length [cm]	78.7	3.58	77.9	4.85	0.426
Lower extremity length [cm]	95.7	4.15	95.7	4.13	0.988
Sitting height [cm]	93.3	4.15	94.5	3.56	0.224
Arm span [cm]	181.0	7.81	185.3	8.11	0.032
Biacromial diameter [cm]	42.4	2.04	44.5	2.20	0.000
Deltoid muscle diameter [cm]	47.0	2.40	49.4	3.50	0.001
Chest diameter [cm]	29.7	2.48	31.3	2.50	0.014
Chest depth [cm]	20.7	1.68	21.6	2.86	0.095
Biiliocristal diameter [cm]	28.8	1.77	30.1	2.52	0.020
Bitrochanteric breadth [cm]	33.1	1.73	34.4	2.36	0.013
Foot length [cm]	26.9	1.34	27.7	1.35	0.027
Foot breadth [cm]	10.1	0.50	10.5	0.82	0.008
Elbow breadth [cm]	7.1	0.33	7.4	0.37	0.002
Interstyloid breadth [cm]	5.9	0.26	6.1	0.29	0.000
Knee breadth [cm]	10.1	0.57	10.5	0.70	0.009

Most measured anthropometric features differentiate both groups of athletes. Body height of athletes from both sets is similar (178.1 ± 7.4 cm in set I and 180.1 ± 6.9 cm in set II). Consequently, upper and lower limbs length and trunk length (sitting height) are alike. Significantly greater arm span was observed in athletes from set II. Also body mass of those athletes is significantly higher (88.5±13.4 kg vs. 77.3±9.5 kg).

All measured widths of the trunk and epiphyses are also larger in the second group. Significant differences in favour of athletes from second set were noted also in the case of body circumferences. The thickness of skinfolds is similar in both groups. The absolute amount of lean body mass, body fat content and water content (in kg) determined using BIA method significantly prevail in athletes from set II. Percentage share of those components does not, however, indicate significant differentiation between both groups.

All participants are mesomorphs, however the distribution of mesomorphic and ectomorphic components significantly differs in both groups. No significant differences were found between groups in terms of

Table 2. Statistical characteristics of the circumference measurements

Variable	I group (n = 51)		II group (n = 23)		Student`s t-test [p]
	Mean	SD	Mean	SD	
Neck circumference [cm]	39.7	1.80	41.3	2.99	0.007
Shoulder circumference [cm]	118.0	5.05	125.2	9.22	0.000
Chest circumference [cm]	100.0	5.18	106.1	10.01	0.001
Waist circumference [cm]	80.5	5.31	85.9	10.75	0.005
Arm circum. – relaxed [cm]	32.5	2.30	35.4	3.18	0.000
Arm circum. – contracted [cm]	35.7	2.57	39.1	3.56	0.000
Max. forearm circumference [cm]	28.0	1.25	30.7	5.23	0.001
Hip circumference [cm]	96.5	4.83	101.2	7.60	0.002
Maximal thigh circumference [cm]	57.8	3.47	61.2	5.13	0.001
Maximal calf circumference [cm]	37.4	2.16	40.3	3.37	0.000

endomorphy. In set I the somatotype can be depicted with the following formula: 2.1-5.8-2.1, whereas in set II: 2.2-7.1-1.3 (Table 3).

DISCUSSION

Studies have confirmed that appropriate level of motor performance as well as appropriately developed anthropometric features, which are believed to be characteristic for these sports, are decisive for high efficiency of an athlete [6].

The development level of body build components (endomorphy, mesomorpy, ectomorphy) of athletes, who participated in the study, confirms previous results about somatotypes characteristic for combat sport athletes [10, 13, 16]. Clear dominance of mesomorphy in athletes from set II indicates that their muscle mass is well-developed what is related to muscle hypertrophy and greater skeletal massiveness. As a consequence static strength is increased because strength is proportional to cross-section area of a muscle[18].

Both judo and ju-jitsu athletes often use isometric strength during contact with competitor. Optimal handgrip force ensures proper grip of an opponent for judoga and use of selected fight technique. Handgrip force turned out to be differentiating factor. Medallists obtained values equal to 51±10 kG for the right hand and 49±10 kG for the left hand. Athletes with lower sporting performance obtained 42±11 kG and 40±10 kG respectively.

Our research revealed that the difference in right handgrip strength between both distinguished groups (set I 47.1 ±7.95 kG and set II 54.6 ±9.49 kG) is slightly smaller than the difference among medallists and athletes with lower sporting performance found in research conducted by Franchini et al.[6]. However, in our research athletes were not differentiated in terms of sporting performance. Therefore, the result of our study should be interpreted as the effect of larger muscle mass of athletes from set II but not as a result of their sporting skills.

Similar results were presented by Gutiérrez Sanchez et al. [19] in their research on the relationship between handgrip strength and results obtained by judo athletes. They studied men and women who participated in Junior Championship of Galicia 2008 (Spain). Among men no differences were found in handgrip strength between medallists and non-medallists. Significant relations between strength and results obtained during competitions were manifested in women. The authors concluded that judokas' success is influenced by better skills, coordination and greater strength of an athlete.

Lewandowska et al. [15]studied relations between somatotype and the level of strength and power in judokas. Their results indicate that muscle force moments and power have a significant positive correlation with the level of mesomorphy and negative correlation with the level of ectomorphy. They also emphasized that adequate level of other morphological features is important to achieve adequate efficiency in judo. They stated that judo athletes should be strongly build (especially as for upper body parts), should have massive skeleton and well-developed leg muscles. These traits, in combination with high level of muscle strength, substantially enable effectiveness during a fight [15].

Table 3. Statistical characteristics of skinfold thickness, body tissue composition, somatotype and BMI

Variable	I group (n = 51)		II group (n = 23)		Student`s t-test [p]
	Mean	SD	Mean	SD	
Subscapular skinfold thickness [mm]	10.1	2.86	10.5	3.65	0.628
Triceps skinfold thickness [mm]	5.0	2.39	4.5	1.06	0.341
Suprailiac skinfold thickness [mm]	7.6	2.99	8.7	3.83	0.185
Abdominal skinfold thickness [mm]	9.2	3.72	10.4	5.33	0.268
Calf skinfold thickness [mm]	4.6	1.72	4.9	1.81	0.501
Fat-free mass [kg]	65.3	6.98	72.9	10.46	0.000
Total body water [kg]	47.8	5.04	53.4	7.66	0.000
Body cell mass [kg]	38.4	4.02	43.4	6.13	0.000
Fat mass [kg]	12.1	4.26	15.6	7.78	0.014
Fat mass [%]	15.4	4.21	17.0	5.28	0.152
Fat-free mass [%]	84.6	4.21	83.0	5.28	0.152
Total body water [%]	62.0	3.15	60.7	3.88	0.132
Body cell mass [%]	58.9	1.98	59.6	2.35	0.182
Endomorphy	2.1	0.73	2.2	0.74	0.647
Mesomorphy	5.8	1.01	7.1	1.41	0.000
Ectomorphy	2.1	0.85	1.3	0.84	0.000
BMI	24.4	1.95	27.2	3.79	0.000

Table 4. Statistical characteristics of the motor test results

Variable	I group		II group		Student`s t-test [p]
	Mean	SD	Mean	SD	
Right handgrip strength [kG]	47.1	7.95	54.6	9.49	0.001
Back strength [kG]	119.8	14.56	164.3	13.94	0.000
Flexed arm hang [s]	40.9	9.29	34.8	13.71	0.029
Standing long jump [cm]	232.0	20.45	224.8	21.92	0.179
Sit-ups [n]	34.5	4.46	31.7	5.05	0.022

Similar results with respect to factors affecting the quality of throwing (*nage waza*) in judo were obtained by Sertić et al. [7]. They suggested that strong development of arm and shoulder girdle muscles allow for more effective performance of those judo techniques. Athletes who are build in this manner are better in knocking a competitor off balance. This is facilitated by adequate body mass and generation of force exerting more pressure during direct contact with a competitor.

Franchini et al. [6] concluded that in comparison with non-active people judo athletes have significantly larger circumferences of an arm, forearm, wrist, calf and ankle. The results confirm high importance of strongly developed limb segments in the effectiveness of a competitor during a fight. Elite athletes and those with lower skills do not differ in thickness of skinfolds [6]. On the other hand, research results obtained by Kubo et al. [20] revealed that athletes with higher sporting skills had lower proportion of body fat than athletes with lower sporting skills. At the same time, elite combat sports athletes exhibited larger proportion of lean body mass. Considerable differences were found as for the development level of arm muscles.

In our study no differences in adiposity were noted between the groups. It should be pointed out that measured skinfolds were quite thin in both groups. At the same time, circumferences of the limbs indicating musculature are significantly larger in group II. These results suggest that tested combat sports athletes attempt to reduce body fat regardless of weight category. Low adiposity in various body parts certainly has positive impact on accelerations and fast reactions to the opponent's actions, what is very important due to the nature of a fight [21].

Clear dominance of athletes from set II with regard to static strength described above results from greater body mass. It has, however, negative impact on their strength endurance. The results obtained by athletes from set II during hang on the bar (34.8 ±13.71 s) are significantly lower than in athletes from set I (40.9±9.29 s). The specificity of motor test should be taken into account, while interpreting the above-mentioned differences. Its execution is associated with supporting body mass acting against gravity force. Large body mass results not only from muscle development but also skeletal and adipose tissue development. Although it determines larger absolute strength, it also forces greater muscle work.

It is difficult to assess strength endurance of abdominal muscles in tested athletes because most authors list the number of sit-ups performed during a test that lasts for 1 minute [4, 22, 23]. It is, however, known that muscle work in judo and ju-jitsu athletes during a fight is very intense [4].

CONCLUSIONS

Tested judo and ju-jitsu athletes have different level of static strength and strength endurance. Those features enter into relations with other features of body build. Athletes with larger body mass and higher values of width parameters and body circumferences can be characterized by greater static strength. Therefore, they can be characterized with significantly higher level of mesomorphy. No differences in thickness of skinfolds were found, what may indicate that all tested athletes implement adequate control over tissue composition. Greater level of static strength is linked with lower strength endurance in tested athletes. No differences between groups were found regarding dynamic strength of lower limbs measured with length of standing broad jump. Such result may be explained by the fact that similarity of speed and strength abilities is one of the basic adaptative effects observed in people who train judo or ju-jistu for many years.

The results suggest the necessity for combat sports athletes (judo, ju-jitsu) to adjust suitable fight techniques during offensive and defensive actions according to their somatic predispositions.

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COMPETING INTERESTS

The authors declare they have no competing interests.

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