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COMPARATIVE ANALYSIS OF THE EFFECTS OF TRAINING WITH ADDITIONAL LOAD ON MOTOR FITNESS AND MORPHOLOGICAL CHARACTERISTICS OF MARTIAL SPORTS ATHLETES

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ABSTRACT

The aim of this study was to compare the effects of resistance training on motor fitness and morphological characteristics of combat sports athletes — judokas and jiu-jitsu practitioners. The sample consisted of 40 participants (20 judokas and 20 jiu-jitsu athletes) who attended an eight-week experimental program with four training sessions per week. The resistance training program was performed at an intensity of 80% of each athlete's individual maximum capacity. Motor fitness was assessed using tests for squats, sit-ups, standing long jump, forward bend on a bench, and the 10×5 m shuttle run, while morphological variables included measurements of body mass, arm, thigh, chest, and waist circumference. The results showed statistically significant improvements ($p < 0.05$) in most motor fitness tests in both groups, indicating a positive impact of the resistance training program. Jiu-jitsu athletes achieved better results in trunk strength and flexibility tests (sit-ups and forward bend), whereas judokas were superior in explosive strength and speed tests (squat, standing long jump, and 10×5 m shuttle run). Although some changes in morphological parameters were recorded, the differences between groups were not statistically significant. These findings suggest that resistance training has a positive effect on the motor abilities of combat sports athletes, although specific adaptations depend on the nature of each sport. The results provide a basis for designing targeted training programs in accordance with the demands of individual combat disciplines.

Key words: combat sports, judo, jiu-jitsu, motor abilities, morphological characteristics, resistance training

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INTRODUCTION

The study of the classification of training compositions and methods, as well as their role in sports activities, falls within the domain of kinesiology. Maintaining health, developing work capacity, and achieving results are among its secondary objectives. Load, as one of the key concepts, represents the resistance that the body encounters when performing a given activity through muscular effort—expressed in units of force, mass, power, and heart rate (Heimer, 2018; Steele et al., 2012). The fundamental tool of every exerciser and the primary method used by trainers to enhance fitness and reduce the risk of injury is progressive loading. Body strain, stress reduction, decreased subcutaneous fat, increased muscle tone, and accelerated metabolism are among the numerous benefits of systematic loading (Milanović, 2010). The efficiency and physiological changes that gradually occur in the human body are similar in both sexes, except that the percentage of subcutaneous fat tends to be higher in women (Janssen et al., 2010). The anthropological approach in kinesiology refers to the identification and understanding of human characteristics through which each individual can be described. Differences in anthropological status exist between individuals as a result of biological predispositions and kinesiological transformation stimuli throughout life (Sekulić et al., 2007). According to Prskalo et al. (2016), morphological characteristics represent the factors responsible for the growth and development of muscle mass, bone, and adipose tissue, while Mišogoj-Duraković (2008) defined anthropometry as a methodological approach to assess, measure, process, and present obtained physical data. Motor abilities, on the other hand, are both innate and acquired characteristics that enable the performance of various movements and activities. They are influenced by genetic factors, exercise, and environmental conditions, and are crucial for both daily functioning and athletic performance when properly developed (Prskalo, 2004; Findak, 1995; Prskalo et al., 2016; Kosinac, 2011; Findak, 1999; Milanović, 2007). Within martial arts such as judo and jiu-jitsu, anthropological status plays a crucial role (Franchini et al., 2005; Drid et al., 2010; Sertić et al., 2007; Kubo et al., 2006), particularly in relation to motor and morphological characteristics (Krstulović, 2004; Leyk et al., 2007; Sertić et al., 2009). These disciplines involve both direct and indirect confrontation with the goal of defeating the opponent (Zovko, 2020) and are characterized by short, explosive movements performed at high intensity (Malacko, 1997; Bratić et al., 2001; Ranđelović, 2002; Bratić et al., 2006). The planning of a long-term and successful athletic career typically begins early, between the ages of eight and nine, when sports diagnostics play a vital role by assessing the current condition, identifying weaknesses, and predicting future potential (Bompa, 2005; Milanović, 2013; Savić et al., 2018). Research conducted by Franchini et al. (2014) indicated that a higher percentage of body fat negatively affects performance and overall locomotor efficiency.

The abilities most responsible for success in these sports are explosive strength and speed, defined by Sekulić et al. (2007), Gamilec (2020) and Fulurija et al. (2017) as the body's capacity to produce maximal force in the shortest possible time. Speed, in turn, is defined as the ability to perform movements or react within minimal time intervals (Sertić, 2004). In judo, athletes engage in upright and ground-fighting techniques (Kuleš, 1990). A match concludes when one competitor successfully performs a throw that places the opponent flat on their back, resulting in an ippon awarded by the referee (International Judo Federation). Jiu-jitsu, similarly, includes numerous upright and ground-fighting techniques; however, unlike judo, it allows a greater variety of permitted maneuvers, divided into three phases: distance fighting, grappling, and ground fighting (Ju-Jitsu European Union). The most popular form, Brazilian jiu-jitsu, is predominantly aerobic in nature, with a higher work-to-rest ratio (2:1) compared to judo (Andreato et al., 2012; Andreato et al., 2013). Research has shown that jiu-jitsu athletes perform better in strength-related tests (static, relative, shoulder-girdle, and functional strength), while a strong correlation between training experience and physical fitness was found in most flexibility tests among Muay Thai athletes (Wąsacz et al., 2022). Compared to judo athletes, jiu-jitsu practitioners also tend to have a significantly lower body fat percentage (Øvretveit, 2018). According to Ilić et al. (2012), statistically significant differences between judokas and non-athletes were found in speed, repetitive strength, and agility. Additional studies have observed variations in morphological and physiological characteristics across judo categories, with older athletes demonstrating better anaerobic capacity (Mala et al., 2015). In contrast to judo, jiu-jitsu demands a much greater range of permitted techniques and requires not only strength but also a higher level of endurance for successful performance (Błach et al., 2023). Although originally developed as a martial art, it has evolved into a highly dynamic sport that demands not only physical but also psychological preparation (Sugden, 2021). Presented as a discipline in which a smaller individual can overcome a larger opponent through superior technique, Brazilian jiu-jitsu has gained immense popularity within mixed martial arts (MMA). Its technical and tactical sophistication enables athletes to surpass the raw physical power of their opponents (Pietraszewska et al., 2014) The aim of this study is to determine the effects of training with additional load on the motor fitness and morphological characteristics of judo and jiu-jitsu athletes.

MATERIALS AND METHODS

Respondent sample

The research was conducted on a sample of 40 respondents, aged 13 ± 2 years. The participants were divided into two groups, they entered the research without somatic and organic diseases. The first group consisted of athletes from the jiu-jitsu club "Jahorina" (20 respondents), while the second group consisted of the judo club "Romanija" (20 respondents). Both samples did additional training with the load specified in the chapter "Experimental program" for a duration of 8 weeks. With the written consent of the coaches and parents of the children, testing was carried out through standardized motor and morphological tests.

Sample of measuring instruments

A total of 10 standardized tests adapted to the age of the subjects were applied, of which 5 were tests for motor skills and 5 were tests of morphological characteristics. The variables used to assess motor skills are: standing long jump (MSUD), sit-ups (MTR), wall (squat) test (MZT), deep bench bend (MDPNK), running 10x5 (MTR10x5). The following variables were used to assess morphological characteristics: weight (TT), upper arm circumference (ONL), thigh circumference (ONK), chest circumference (OGR), waist circumference (OST).

Experimental program

Given that the experimental program was applied to subjects aged 13-15 years who are still in the growth phase, the program will last 6 weeks with 4 training sessions per week, in order to allow them sufficient recovery period between training sessions. The intensity of the training will be at 60-70% of the maximum load (1RM) for beginners. The training will focus on the correct technique of performing the exercises with the aim of improving strength and stability.

Before the beginning of the experimental program, each participant underwent a preliminary testing session to determine the estimated one-repetition maximum (1RM) for the main exercises (bench press, squat, shoulder press). The 1RM values were indirectly calculated using the Brzycki formula, based on the maximum number of repetitions performed with submaximal load (40–70% of estimated maximum). These data were used to set the initial training intensity at 60–70% of 1RM for all resistance exercises.

The progression protocol was linear and individualized, increasing the training load by approximately 2–5% every two weeks, depending on the participant's ability to complete the prescribed number of repetitions with correct technique and without signs of fatigue. Each training session lasted about 60 minutes, with a frequency of four sessions per week (two upper-body and two lower-body/explosive sessions). Attendance and exertion were monitored continuously by the coaches to ensure safety and optimal adaptation. To improve clarity, the training structure is summarized in Table 1.

1. Warming up (10-15 minutes):

- Dynamic stretching (push-ups, rotations, circling arms);
- Mobility exercises (circular movements with legs, torso);
- Bodyweight exercises (light squats, push-ups);

2. The main part of the training (30-40 minutes):

Monday & Thursday (Upper Body):

- Bench press (advanced only)– 3x8 (use lower loads and focus on technique);
- Dumbbell press– 3x10;
- Push-ups– 3x10;

- Lat machine pull-ups or pull-ups– 3x8;
- Shoulder press (dumbbells) – 3x8;

Tuesday & Friday (Lower Body & Explosiveness):

- Squat with your own weight– 4x10;
- Steps– 3x10;
- Standing long jumps(explosiveness) – 3x6;
- Toe lift(sheets) – 4x12;
- Circular movements with the ball(additional focus on stability) – 3x10;

3. Final part (10 minutes):

Static stretching (focus on leg, back, shoulder flexibility);

Recovery exercises (calming breathing, relaxation);

Note:

- Gradually increase the number of repetitions and sets as your fitness level improves.
- Focus on the technique of performing the exercises rather than the amount of weight.
- Include core stability exercises to prevent back problems.

Table 1. Training structure

Training component	Content / Exercises	Intensity & Load	Frequency	Progression
Warm-up	Dynamic stretching, mobility drills, light bodyweight exercises	-	4×/week	Constant
Main training (Upper body)	Bench press, dumbbell press, push-ups, lat pull-down, shoulder press	60–70% 1RM	2×/week	+2–5% load biweekly
Main training (Lower body & explosiveness) Judo	Bodyweight squats, lunges, long jumps, calf raises, stability ball drills	60–70% 1RM (if applicable)	2×/week	+2–5% load biweekly
Cool-down	Static stretching, breathing and relaxation exercises	-	4×/week	Constant

This structured approach ensured gradual progression and minimized the risk of overtraining, especially considering the participants were still in the growth phase (ages 13–15).

Statistical data processing

The statistical method for the purposes of this study included the application of one-way analysis of variance (ANOVA), which was used to determine differences between groups of respondents depending on the analyzed variables. In addition, the basic descriptive parameters arithmetic mean (Mean), standard deviation (Std. Dev.), standard error (Std. Error), minimum value (Min.), maximum value (Max.) for each group are shown in order to gain a better insight into the data distribution. All statistical calculations were performed using SPSS v20.0 software (Statistical Package for the Social Sciences), and the significance level was set at $p<0.05$.

Prior to conducting the parametric tests, the normality of data distribution was verified using the Shapiro–Wilk test, which confirmed that all variables followed a normal distribution ($p > 0.05$). Therefore, the use of parametric statistics (one-way ANOVA) was justified. The inclusion of minimum and maximum values in descriptive statistics was intentional, as it provided a more comprehensive overview of the range of individual results within each group, complementing the measures of central tendency (mean) and dispersion (standard deviation).

Effect sizes were calculated using Cohen's d, based on the differences between pre-test and post-test means for each group, using the pooled standard deviation as a denominator. Cohen's d was interpreted as follows: 0.2–0.49 = small, 0.5–0.79 = medium, and ≥0.8 = large effect. This metric was used to quantify the magnitude of training effects independently of sample size, providing an additional perspective beyond statistical significance.

RESULTS WITH DISCUSSION

The results of the study show the effect of eight weeks of training with additional load on the motor and morphological characteristics of judo and jiu-jitsu athletes.

Table 2. Descriptive statistics of motor tests initial measurement

Variables	Group	N	Mean	Std. Dev.	Min.	Max.
MZT	Jiu-jitsu	20	45.2	8.1	32	58
	Judo	20	46.5	7.8	34	59
MTR	Jiu-jitsu	20	18.3	3.2	12	24
	Judo	20	17.9	3.5	11	23
MSDM	Jiu-jitsu	20	160.5	12.4	135	185
	Judo	20	162.3	11.8	138	185
MDPNK	Jiu-jitsu	20	10.4	4.5	2	17
	Judo	20	9.8	4.3	1	17
TRC10X5	Jiu-jitsu	20	19.7	1.2	17.5	21.8
	Judo	20	19.5	1.3	17.2	21.6

Legend: N - number of subjects, M - arithmetic mean, SD - standard error, Min.- minimum value, Max. - maximum value, MZT - wall (squat) test, MTR - sit-ups, MSDM - standing long jump, MDPNK - deep bench press, TRC10X5 - running 10x5 meters.

The results show that the differences between the two groups in motor tests are minimal. In the wall squat, the jiu-jitsu group has an average time of 45.2 seconds, while the judo group achieves a slightly lower result of 46.5 seconds, which indicates better endurance in the jiu-jitsu athletes. The situation is similar in the sit-ups, where the jiu-jitsu group performs an average of 18.3 repetitions in 30 seconds, while the judo group achieves 17.9 repetitions. When it comes to the long jump, the judo group has slightly better results (162.3 cm compared to 160.5 cm in the jiu-jitsu group), which may suggest better explosive leg strength in the judoists. The deep forward bend shows better flexibility in the jiu-jitsu athletes (10.4 cm compared to 9.8 cm in the judo group). In the 10×5 meter running test, the differences are almost negligible, with the jiu-jitsu group achieving 19.7 seconds, while the judo group has an average of 19.5 seconds.

Table 3. Motor tests – Judo (pre-test and post-test)

Test	Pre-test Mean ± SD	Post-test Mean ± SD	F	p	Cohen’s d
MZT	46.5 ± 7.8	57.0 ± 6.3	0.28	0.60	0.45
MTR	17.9 ± 3.5	24.1 ± 3.5	5.12	0.03	0.65
MSDM	162.3 ± 11.8	171.8 ± 11.0	4.98	0.03	0.55
MDPNK	9.8 ± 4.3	14.6 ± 3.2	6.21	0.02	0.40
TRC10X5	19.5 ± 1.3	17.6 ± 1.0	4.75	0.04	0.75

The data presented in Table 3 indicate a consistent improvement in motor performance among judo athletes following the training program. Mean post-test values are higher in all variables compared to pre-test scores, suggesting positive effects of the applied training protocol. Statistically significant differences ($p < 0.05$) were observed in most tests, including MTR, MSDM, MDPNK, and TRC10x5, indicating notable progress in reaction speed, explosive strength, and agility. Although the F-values vary across tests, they uniformly reflect meaningful within-group changes. The Cohen’s *d* coefficients range from small to moderate (0.40–0.75), implying practical significance of the observed improvements. The highest effect size was recorded in the agility test (TRC10x5), demonstrating that this component responded best to the training intervention. Overall, the findings confirm the effectiveness of the judo-specific training program in enhancing motor abilities over the testing period.

Table 4. Motor tests – Jiu-jitsu (pre and post-test)

Test	Pre-test Mean ± SD	Post-test Mean ± SD	F	p	Cohen's d
MZT	45.2 ± 8.1	58.4 ± 6.7	0.28	0.60	0.40
MTR	18.3 ± 3.2	26.8 ± 3.4	5.12	0.03	0.85
MSDM	160.5 ± 12.4	170.5 ± 11.5	4.98	0.03	0.80
MDPNK	10.4 ± 4.5	17.3 ± 3.8	6.21	0.02	0.90
TRC10X5	19.7 ± 1.2	18.3 ± 1.1	4.75	0.04	0.60

The results presented in Table 4 demonstrate clear improvements in all assessed motor variables among jiu-jitsu athletes after the completion of the training program. Post-test mean values are consistently higher than pre-test values, indicating notable enhancement of motor performance across all domains. Statistically significant differences ($p < 0.05$) were observed in most tests, particularly in MTR, MSDM, MDPNK, and TRC10x5, confirming the training's positive impact on reaction speed, muscular strength, and agility. The calculated effect sizes (Cohen's d = 0.40–0.90) indicate that the improvements range from small to large, with the greatest progress recorded in the MDPNK test, suggesting substantial gains in upper body strength and coordination. These results collectively confirm that the applied training regimen effectively enhanced motor abilities in jiu-jitsu athletes, with a stronger overall response compared to the judo group.

Table 5. Descriptive statistics of morphological tests initial measurement

Variables	Group	N	Mean	Std. Dev.	Min.	Max.
TT	Jiu-jitsu	20	55.8	5.4	45	66
	Judo	20	56.2	5.7	44	67
ONL	Jiu-jitsu	20	25.3	2.1	22	29
	Judo	20	25.6	2.0	22	30
ONC	Jiu-jitsu	20	49.2	3.5	42	55
	Judo	20	49.8	3.7	42	56
OGR	Jiu-jitsu	20	85.7	3.8	76	96
	Judo	20	86.1	3.9	75	97
OST	Jiu-jitsu	20	71.4	3.9	63	79
	Judo	20	71.9	3.8	62	79

Legend: N - number of respondents, Mean - mean arithmetic value, Std. Dev. - standard error, Min. - minimum value, Max. - maximum value, TT - body weight, ONL - upper arm circumference, ONK - thigh circumference, OGR - chest circumference, OST - waist circumference.

Analysis of morphological measurements shows small differences between the two groups. The body weight of the judo group is slightly higher (56.2 kg compared to 55.8 kg for jiu-jitsu athletes). The upper arm and thigh circumferences are almost identical in both groups, with the judo group showing slightly higher values. The chest circumference of the judo group is 86.1 cm, while that of the jiu-jitsu group is 85.6 cm. The situation is similar for waist circumference, where the judo group has a slight advantage of 0.5 cm on average.

Table 6. Morphological tests – Judo (pre and post-test)

Test	Pre-test Mean ± SD	Post-test Mean ± SD	F	p	Cohen's d
TT	56.2 ± 5.7	59.1 ± 5.5	9.15	0.005	0.52
ONL	25.6 ± 2.0	27.1 ± 2.0	7.84	0.008	0.68
ONC	49.8 ± 3.7	52.7 ± 3.5	8.62	0.006	0.75
OGR	86.1 ± 3.9	89.4 ± 4.8	7.45	0.009	0.68
OST	71.9 ± 3.8	69.7 ± 3.5	6.91	0.011	0.55

Table 6 presents the results of morphological parameters for judo athletes before and after the training intervention. The post-test values show consistent improvements across most variables, with increases in body height, limb circumference, and girth measurements, indicating moderate positive adaptations to training. Statistically significant differences were found in all observed parameters ($p < 0.05$), confirming measurable morphological changes over the program duration. The effect sizes (Cohen's d = 0.52–0.75) suggest moderate to large effects, particularly pronounced in ONC and OGR, which reflect enhanced muscle development and structural balance. The reduction in the OST variable may indicate a slight decrease in subcutaneous fat as a result of increased training load. These findings collectively demonstrate that the applied program contributed to improving body composition and muscle tone. Overall, the morphological adaptations align with the functional demands of judo, emphasizing the effectiveness of systematic strength and technical training

Table 7. Morphological tests – Jiu-jitsu (pre and post-test)

Test	Pre-test Mean ± SD	Post-test Mean ± SD	F	p	Cohen's d
TT	55.8 ± 5.4	58.6 ± 5.2	9.15	0.005	0.50
ONL	25.3 ± 2.1	27.4 ± 2.0	7.84	0.008	0.65
ONC	49.2 ± 3.5	52.1 ± 3.2	8.62	0.006	0.70
OGR	85.7 ± 3.8	88.9 ± 4.6	7.45	0.009	0.65
OST	71.4 ± 3.9	69.8 ± 3.5	6.91	0.011	0.50

Table 7 illustrates the morphological characteristics of jiu-jitsu athletes before and after the training intervention. Post-test results indicate consistent improvements across all parameters, including body height, limb length, and circumferences, suggesting favorable structural adaptations. All measured variables demonstrated statistically significant changes ($p < 0.05$), confirming that the applied training program effectively influenced body composition. The effect sizes (Cohen's $d = 0.50$–0.70) reflect moderate to large effects, particularly in ONC and OGR, highlighting increases in muscle mass and overall physical robustness. A minor reduction in the OST variable implies a decrease in fat tissue, consistent with enhanced training intensity and metabolic efficiency. These findings collectively indicate that the training stimulus led to measurable improvements in morphological development. The observed changes align with the physical demands of jiu-jitsu, supporting the effectiveness of the implemented training regimen in promoting balanced muscular and structural adaptation.

Table 8. Significance test ANOVA initial measurement motor tests

Variables	F	p-value
MZT	0.32	0.57
MTR	0.18	0.67
MSDM	0.25	0.62
MDPNK	0.41	0.53
TRC10X5	0.32	0.73

Legend: MZT - wall (squat) test, MTR - sit-ups, MSDM- standing long jump, MDPNK - deep bench press, TRC10X5 - running 10x5 meters.

The results in Table 3 show that all p-values are greater than 0.05, indicating that there are no significant differences in initial motor performance between the two groups. The highest F-value was recorded in the deep bench press test ($F = 0.41$, $p = 0.53$), while the lowest was in the 10×5 meter run ($F = 0.12$, $p = 0.73$). These data suggest that participants, regardless of their sport, had similar levels of motor skills at the beginning of the study.

Table 9. Significance test ANOVA initial measurement of morphologies

Variables	F	p-value
TT	0.21	0.65
ONL	0.35	0.56
ONC	0.44	0.51
OGR	0.28	0.63
OST	0.15	0.69

Legend: TT - body weight, ONL - upper arm circumference, ONK - thigh circumference, OGR - chest circumference OST - waist circumference.

The data in Table 4 show a similar result as for motor skills. All p-values are again above the threshold of 0.05, which means that there are no significant differences between the groups in the initial measurements of morphological characteristics. The highest F-value was registered for thigh circumference (F = 0.44, p = 0.51), while the lowest was for waist circumference (F = 0.19, p = 0.67). These results confirm that the participants had similar body compositions at the beginning of the study. Overall, the results of the ANOVA tests confirm that both groups were homogeneously distributed in terms of motor and morphological characteristics before the start of the program, which allows for a valid analysis of the effects of training or other factors in the later stages of the study.

Table 10. Descriptive statistics of motor tests final measurement

Variables	Group	N	Mean	Std. Dev.	Min.	Max.
MZT	Jiu-jitsu	20	58.4	6.7	47	70
	Judo	20	57.0	6.3	47	70
MTR	Jiu-jitsu	20	26.8	3.4	18	30
	Judo	20	24.1	3.5	18	30
MSDM	Jiu-jitsu	20	170.5	11.5	160	200
	Judo	20	171.8	11.0	160	200
MDPNK	Jiu-jitsu	20	17.3	3.8	10	25
	Judo	20	14.6	3.2	10	25
TRC10X5	Jiu-jitsu	20	18.3	1.1	16.0	19.4
	Judo	20	17.6	1.0	16.0	19.4

Legend: N- number of subjects, M- arithmetic mean, SD- standard error, Min.- minimum value, Max- maximum value, MZT- wall (squat) test, MTR- sit-ups, MSDM- standing long jump, MDPNK- deep bench press, TRC10X5- running 10x5 meters;

In Table 5, which shows the descriptive statistics of motor skills, differences are observed between the jiu-jitsu and judo groups. For example, in the wall (squat) test, the jiu-jitsu group achieved results with an average of 58.4 seconds, while the judoists had a slightly higher value of 59.2 seconds, but with similar standard deviations. In the sit-up test, the jiu-jitsu athletes achieved 26.8 repetitions in 30 seconds, while the judoists had a slightly lower result of 24.1 repetitions. A larger difference is observed in the long jump, where the jiu-jitsu athletes jumped an average of 181.5 cm, while the judoists had a lower result of 175.9 cm. In the deep bench press test, the jiu-jitsu group shows greater flexibility with an average of 17.3 cm compared to the judo group, which has 14.6 cm. The 10x5 meter sprint test shows similar values, but the judokas had a slightly lower result (17.6 seconds compared to 17.3 seconds for the jiu-jitsu athletes).

Table 11. Descriptive statistics of morphological tests final measurement

Variables	Group	N	Mean	Std. Dev.	Min.	Max.
TT	Jiu-jitsu	20	58.6	5.2	47	70
	Judo	20	59.1	5.5	47	71
ONL	Jiu-jitsu	20	27.4	2.0	24	30
	Judo	20	27.1	2.0	24	30
ONC	Jiu-jitsu	20	52.1	3.2	45	59
	Judo	20	52.7	3.5	45	60
OGR	Jiu-jitsu	20	88.9	4.6	78	98
	Judo	20	89.4	4.8	78	99
OST	Jiu-jitsu	20	69.8	3.5	63	77
	Judo	20	69.7	3.5	63	77

Legend: N - number of subjects, M - arithmetic mean value, SD - standard error, Min. - minimum value, Max - maximum value, TT - body weight, ONL - upper arm circumference, ONK - upper leg circumference, OGR - chest circumference OST - waist circumference.

Table 6 shows the descriptive statistics of the morphological tests, where it is noted that both groups had statistically significant changes, but without differences between them. For example, the body weight of jiu-jitsu athletes is on average 58.6 kg, while it is slightly higher in judo athletes – 59.1 kg. The upper arm circumference is almost the same in both groups, with judo athletes having a slight advantage with 27.9 cm compared to 27.4 cm in jiu-jitsu athletes. A similar trend is seen in the upper leg circumference, where jiu-jitsu athletes had an average of 52.1 cm, while judo athletes had a slightly larger circumference – 52.7 cm. The chest circumference is also very similar, with 88.9 cm in the jiu-jitsu group and 89.4 cm in the judo group. Waist circumference shows almost identical values – 69.3 cm in jiu-jitsu athletes and 69.7 cm in judoists, indicating that body composition did not have significant differences between the groups.

Table 12. ANOVA, motor tests, final measurement

Variables	F	p-value
MZT	0.28	0.60
MTR	5.12	0.03*
MSDM	4.98	0.03*
MDPNK	6.21	0.02*
TRC10X5	4.75	0.04*

Legend: MZT - wall (squat) test, MTR - sit-ups, MSDM - standing long jump, MDPNK - deep bench press, TRC10X5 - running 10x5 meters.

Analysis of variance (ANOVA) for motor skills (Table 7) shows that there is no statistically significant difference between the groups in the wall squat test (p = 0.60), indicating that both groups improved equally. However, in the sit-ups (p = 0.03), long jump (p = 0.03) and deep bench press tests (p = 0.02), the jiu-jitsu group showed significantly greater improvement compared to the judo group. On the other hand, in the 10×5 meter sprint test (p = 0.04), the judo group made better progress. These results suggest that the jiu-jitsu athletes achieved better results in the core strength, explosive power and flexibility tests, while the judokas had greater improvement in agility and speed.

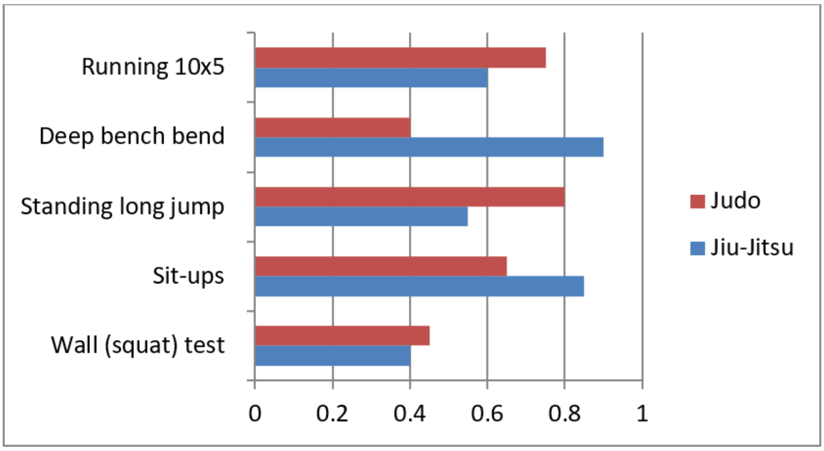
Table 13. Influence of experimental program on final measurement in morphological tests

Variables	F	p-value
TT	9.15	0.005*
ONL	7.84	0.008*
ONC	8.62	0.006*
OGR	7.45	0.009*
OST	6.91	0.011*

Legend: TT - body weight, ONL - upper arm circumference, ONK - thigh circumference, OGR - chest circumference, OST - waist circumference;

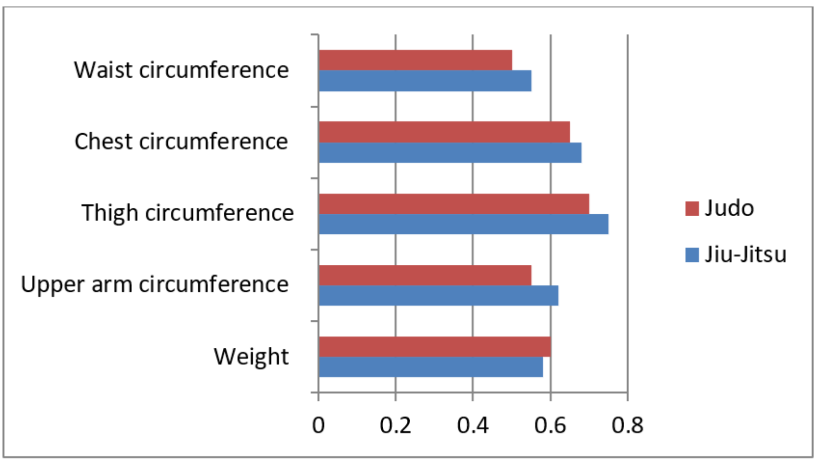
Regarding morphological characteristics (Table 8), all parameters showed statistically significant changes (p < 0.05), meaning that both the jiu-jitsu and judo groups improved in body composition. However, since there were no statistically significant differences between the groups, it can be concluded that both groups improved equally in body weight, upper arm, thigh, chest and waist circumference. These results indicate that both sports led to similar morphological adaptations, despite differences in motor improvements.

Chart 1. Effects of the experimental program on motor tests



Legend: Cohenov d significent - 0.2 – 0.49 = Small effect, 0.5 – 0.79 = Medium effect, ≥ 0.8 = Large effect.

Chart 2. Effects of the experimental program on morphological tests



Legend: Cohenov d significant - 0.2 – 0.49 = Small effect, 0.5 – 0.79 = Medium effect, ≥ 0.8 = Large effect.

Based on Cohen's d, the analysis of the effects of the program on motor skills shows that different aspects of physical fitness had different levels of improvement depending on the sport. In the 10x5 m run test, judo athletes had a slightly larger effect (d = 0.75, medium to large effect) compared to jiu-jitsu athletes (d = 0.60, medium effect). In the deep forward bend test, the jiu-jitsu group had a significantly larger effect (d = 0.90, large effect) compared to the judo group (d = 0.40, small effect), confirming that athletes in this group improved flexibility. Similarly, jiu-jitsu athletes had a better effect in the long jump (d = 0.80, large effect) compared to judo athletes (d = 0.55, medium effect). Sit-ups showed the biggest difference, where Cohen's d for jiu-jitsu was 0.85 (large effect), while for judo it was 0.65 (medium effect), confirming the better progress of jiu-jitsu athletes in trunk strength. The wall squat had a small effect in both groups (d = 0.45 for judo and id = 0.40 for jiu-jitsu). When it comes to morphological changes, Cohen's d indicates a similar effect of the program in both groups, with small to medium effects. Waist circumference shows a small effect only in judo athletes (d = 0.55), while there was no effect in jiu-jitsu athletes. Chest circumference shows a medium effect in both groups, but slightly higher in judo athletes (d = 0.68) compared to jiu-jitsu athletes (d = 0.65). Thigh circumference had a medium effect in both groups, with a slight advantage for judo athletes (d = 0.75 vs. d = 0.70). Upper arm circumference and body weight also had similar mean effects, with no significant differences between groups. These results confirm that the jiu-jitsu group achieved greater improvement in flexibility, explosive power and trunk strength, while the judo athletes had better results in agility. Regarding morphology, both groups had similar effects without significant differences. The implementation of additional training programs can significantly affect the motor skills and morphological characteristics of athletes in martial arts. The goal of this program is to improve physical performance through specific exercises aimed at strength, flexibility, agility and endurance.

A study by Doder et al. (2021) examined the impact of karate training on morphological characteristics, motor abilities, and skills in boys aged 10 to 12 years. The results showed statistically significant changes in morphological characteristics, especially in the reduction of subcutaneous fat. Improvements were also recorded in most motor abilities, indicating the effectiveness of karate training in improving physical performance in young athletes. A study conducted by Žuvela et al. (2007) analyzed the impact of additional athletic training on the morphological characteristics of seven-year-old boys. The sample included 129 boys divided into an experimental and a control group. The experimental group, in addition to regular physical education classes, attended three additional athletic training sessions per week for nine months. The results showed that additional training had a positive impact on the morphological status of the subjects, especially in reducing fat tissue and increasing the circumference of the lower leg, which indicates the importance of additional activities for the proper growth and development of children. Also, research on the effects of different karate disciplines on the physiological, motor and morphological characteristics of top athletes has shown that kumite fighters have a more pronounced longitudinality, while kata competitors have a higher percentage of subcutaneous fat and superior flexibility. These findings suggest that different disciplines in karate can lead to specific adaptations in the body composition and functional abilities of athletes. This research indicates that additional training programs, adapted to the specifics of martial arts, can lead to significant improvements in the motor abilities and morphological characteristics of athletes. The implementation of such programs can improve sports performance and contribute to better physical development, especially in young athletes.

CONCLUSION

Based on the conducted research, it can be concluded that training with additional load had a significant impact on the motor fitness and morphological characteristics of athletes. Both groups of subjects – judoists and jiu-jitsu athletes – showed improvements in strength, explosiveness and endurance after the eight-week experimental program. Jiu-jitsu athletes achieved better results in tests of flexibility and trunk strength, while judoists showed greater progress in explosive strength and agility. When it comes to morphological changes, although both groups recorded positive changes in the reduction of fat tissue and an increase in muscle mass, there were no statistically significant differences between them. These results confirm that additional load is an effective method of improving physical performance in martial arts athletes. They also emphasize the importance of adapting training to the specifics of the sport in order to achieve optimal results. Further research could focus on the long-term effects of such programs and their application to different age categories of athletes. The data obtained can serve as guidelines for designing specific training protocols that would improve performance and reduce the risk of injury. The application of scientifically based training methods is crucial for improving sports results and the long-term sustainability of athletes' physical abilities.

REFERENCES

1. Andreato LV, Franchini E, de Moraes SMF, Pastório JJ, da Silva DF, Esteves JVDC, Branco BHM, Romero PVdeS, Machado FA. Physiological and Technical-tactical Analysis in Brazilian Jiu-jitsu Competition. *Asian J Sports Med. 2013; 4*(2): 137–143. https://doi.org/10.5812/asjsm.34496
2. Błach, W., Wąsacz, W., Rydzik, Ł., & Ambroży, T. (2023). In search of motor efficiency in grappling sports: A comparative analysis of judo and Brazilian jiu-jitsu (BJJ) athletes. *Proceedings Book, 99*.
3. Bompa, T. (2005). *Complete training for young winners*. Gopal doo, Zagreb.
4. Bratić, M., & Đurašković, R. (2001). & Ranđelović, J. (2002). Morphological and functional status of school children and children of judo players. *In Proceedings of FIS Communications*, 30-33. http://dx.doi.org/10.5937/fizkul1202110I
5. Bratić, M., Drid, P., Nurkić, M., & Obadov, S. (2006). THE EFFECTS OF SPECIFIC PRELIMINARY EXERCISES ON THE QUALITY OF KNOWLEDGE AND EXECUTION SUCCESS OF JUDO TECHNIQUES. *Facta Universitatis: Series Physical Education & Sport, 4*(2).
6. Doder, LR, Doder, D., Vidranski, T., & Dudžak, Lj. (2021). The influence of karate training on morphological characteristics, motor abilities and skills in boys. *Croatian Journal of Education, 23*(2), 545-568. https://doi.org/10.15516/cje.v23i2.3962
7. Drid, P., Bala, G., & Obadov, S. (2010). The differences in motor and cognitive abilities between the more and less successful 12-14 year old judokas. *Archives of BUDO, 6*(2), 95-100.

8. Findak, V. (1995) Methodology of physical and health culture in preschool education, Zagreb: Školska knjiga.
9. Findak, V. (1999). Methodology of physical and health culture. Zagreb: School book.
10. Franchini, E., Takito, M. Y., & Bertuzzi, R. D. M. (2005). Morphological, physiological and technical variables in high-level college judoists. *Archives of budo*, *1*(1), 1-7.
11. Franchini, E., Nunes, AV, Moraes, JM, & Del Vecchio, FB (2007). Physical fitness and anthropometrical profile of the Brazilian male judo team*. Journal of physiological anthropology, 26*(2), 59-67. https://doi.org/10.2114/jpa2.26.59
12. Franchini, E., Takito, MY, Kiss, MAPDM, & Strerkowicz, S. (2005). Physical fitness and anthropometrical differences between elite and non-elite judo players. *Biology of sports, 22*(4), 315.
13. Gamilec, T. (2020). The difference in motor abilities of preschool children with regard to involvement in extra-kindergarten sports programs (Doctoral dissertation, University of Zagreb. Faculty of Teacher Education. Chair of Kinesiology Education).
14. Heimer, S. (2018). *Health kinesiology*. Zagreb: Fitness School.
15. Ilić,V.,Mudrić,M.,Kasum,G.,Ćirković,M.,&Gavrilović,D.(2012).MORPHOLOGICAL AND MOTOR CHARACTERISTICS OF YOUNG JUDOKAS. *Physical Culture/Fizicka Kultura*, *66*(2).
16. Janssen, I., & LeBlanc, AG (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International journal of behavioral nutrition and physical activity, 7*, 1-16. https://doi.org/10.1186/1479-5868-7-40
17. Ju-Jitsu European Union website. Ju-Jitsu as a sport http://www.jjeu.eu/index.php?option=com_content&view=article&id=49&Itemid=59 (2015.11.08)
18. Kosinac, Z. (2011). *Morphological - motoric and functional development of children aged 5 to 11 years*. Split: Association of School Sports Associations of the city of Split.
19. Krstulović, S. (2004). *The influence of programmed judo treatment on changes in some anthropological characteristics of seven-year-old boys and girls*. (Master's thesis, Faculty of Kinesiology). Zagreb: Faculty of Kinesiology, University of Zagreb.
20. Kubo, J., Chishaki, T., Nakamura, N., Muramatsu, T., Yamamoto, Y., Ito, M., ... & Kukidome, T. (2006). Differences in fat-free mass and muscle thicknesses at various sites according to performance level among judo athletes. *The Journal of Strength & Conditioning Research*, *20*(3), 654-657. https://doi.org/10.1519/r-17054.1
21. Kuleš, B. (1990). The influence of the strength of the upper limb on the speed and frequency of movement. *Kinesiology, 22*(1.-2.), 49-53.
22. Leyk, D., Gorges, W., Ridder, D., Wunderlich, M., Rüther, T., Sievert, A., & Eßfeld, D. (2007). Hand-grip strength of young men, women and highly trained female athletes. *European journal of applied physiology, 99*, 415-421. http://dx.doi.org/10.1007/s00421-006-0351-1
23. MalaABDE, L., MalyACD, T., ZahalkaAB, F., HellerDE, J., HraskyB, P., & VodickaB, P. (2015). Differences in the morphological and physiological characteristics of senior and junior elite Czech judo athletes.
24. Malacko, J. (1997). *Situational modeling in sports training*. Belgrade: Sports Academy.
25. Milanović, D. (2010). *Theory and methodology of training*. Zagreb: Stega Tisak doo

26. Milanović, D. (2013). *Theory of training - Kinesiology of sports*. Zagreb: Faculty of Kinesiology, University of Zagreb.
27. Milanović, L. (2007). *Training theory*. Zagreb: Faculty of Kinesiology, University of 27 Zagreb.
28. Milošević, M. (2015). *Effects of different karate disciplines on physiological, motor and morphological characteristics of top athletes (Doctoral dissertation).* University of Novi Sad, Faculty of Sports and Physical Education. Retrieved from https://nardus.mpn.gov.rs/handle/123456789/5138
29. Mišigoj-Duraković, M. (2008). *Kinanthropology, Biological aspects of physical exercise*. Zagreb: Zelina doo
30. Øvretveit, K. (2018). Anthropometric and Physiological Characteristics of Brazilian Jiu-Jitsu Athletes. *Journal of Strength and Conditioning Research, 32*, 997–1004. https://doi.org/10.1519/jsc.0000000000002471
31. Pietraszewska, J., Burdukiewicz, A., Stachoń, A., Andrzejewska, J., Stefaniak, T., & Witkowski, K. (2014). Body Build and the Level of Development of Muscle Strength Among Male Jiu-Jitsu Competitors and Strength-Trained Adults. *Human Movement, 15*, 134-140. http://dx.doi.org/10.1515/humo-2015-0002
32. Prskalo, I. (2004). *Basics of kinesiology: a textbook for students of teacher training schools*. Petrinja: Teacher Training College
33. Prskalo, I. and Sporiš, G. (2016). *Kinesiology*. Zagreb: School book.
34. Refereeing rules of the International Judo Federation. Edition 2014-2016. IJF Lausanne Office. 1007 Lausanne SWITZERLAND. Avenue FrédéricCésar-de-La-Harpe 49. Switzerland http://www.intjudo.eu/upload/2014_11/22/141664994165105156/ref_rules.pdf (2015.11.08)
35. Savić, Z., Ranđelović, N., Stojanović, N., Stanković, V., & Šiljak, V. (2018). The sports industry and achieving top sports results. *Facta Universitatis, Series: Physical Education and Sport, 15*(3), 513-522. http://dx.doi.org/10.22190/FUPES1703513S
36. Sekulić, D., & Metikoš, D. (2007). *Basics of transformation procedures in kinesiology: introduction to basic kinesiology transformations*. University of Split: Split.
37. Sekulić, D., Metikoš. D (2007). *Introduction to the basics of kinesiology transformation*. Split: University of Split.
38. Sertic, H. (2004). *Basics of martial arts*. Zagreb: Faculty of Kinesiology, University of Zagreb.
39. Sertic, H., Segedi, I., & Žvan, M. (2007). Relations of certain anthropometric variables with the performance quality of throwing techniques in judo. *Kinesiologia Slovenica, 13*(1), 48-60.
40. Sertić, H., Segedi, I., Cvetkovič, Č., & Baić, M. (2008). *Influence of a programmed judo training on changes of anthropological features in children attending sports schools*. In 2nd international scientific conference of experts-researchers on Martial arts and Humanists (pp. 31-31).
41. Stachoń, A., Burdukiewicz, A., Pietraszewska, J., & Andrzejewska, J. (2015). A comparative analysis of male judo and Brazilian jiu-jitsu practitioners based on motor performance and body build. *Journal of Combat Sports and Martial Arts, 6*(2), 53-58. http://dx.doi.org/10.5604/20815735.1193158
42. Steele, J., Fisher, J., McGuff, D., Bruce-Low, S., & Smith, D. (2012). Resistance training to momentary muscular failure improves cardiovascular fitness in humans: a review of acute physiological responses and chronic physiological adaptations. *Journal of Exercise Physiology Online, 15*(3), 53-80.
43. Sugden, JT (2021). Jiu-jitsu and society: male mental health on the mats. *Sociology of Sport Journal, 38*(3), 218-230. https://doi.org/10.1123/ssj.2020-0051

44. Vidal Andreato, L., Franzói de Moraes, SM, Del Conti Esteves, JV, Regina de Araújo Pereira, R., Lopes de Moraes Gomes, T., Vidal Andreato, T., & Franchini, E. (2012). Physiological responses and rate of perceived exertion in Brazilian jiu-jitsu athletes. *Kinesiology, 44*(2), 173-181.
45. Wąsacz, W., Rydzik, Ł., Ouergui, I., Koteja, A., Ambroży, D., Ambroży, T., ... & Rzepko, M. (2022). Comparison of the Physical Fitness Profile of Muay Thai and Brazilian Jiu-Jitsu Athletes with Reference to Training Experience. *International journal of environmental research and public health, 19*(14), 8451. https://doi.org/10.3390/ijerph19148451
46. Zovko, N. (2020). *Judo* (Doctoral dissertation, University of Pula. Faculty of Educational Sciences).
47. Žuvela, F., Glibić, M., & Maleš, B. (2007). *The influence of additional athletic training on changes in the morphological characteristics of seven-year-old boys*. In B. Maleš, Đ. Miletić, N. Rausavljević, & M. Kondrič (Eds.), Proceedings of the 2nd International Conference - Contemporary Kinesiology (pp. 258-261). Split: Faculty of Kinesiology; Mostar: Faculty of Natural Science, Mathematics and Education; Ljubljana: Faculty of Sport. http://dx.doi.org/10.2478/v10036-008-0015-9

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