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DEVELOPMENT OF SPECIFIC STRENGTH SKILLS OF UPPER LIMBS DUE TO TARGETED MOVEMENT INTERVENTION IN JUDOKAS IN CATEGORIES U12 – U16

Věra KNAPPOVÁ, Petr PEŠEK, Patrice MAREK

Abstract:
The presented work deals with the issue of grip strength and its development in the specific environment of combat sports. The research investigation compared the state of strength skills of U12-U16 judokas pre and post targeted movement intervention aimed at grip strength development. Probands were measured with a battery of 3 tests targeting upper limb strength skills and exposed to a targeted movement intervention over a 4-month period to stimulate the development of strength skills central to success in the sport. After the movement intervention, the boys' group showed statistically significant improvement in all tested parameters. Grip strength, paradoxically, improved mainly in the non-dominant upper limb.

Keywords: *judo, older school age, strength skills, training intervention, dynamometry.*

1. INTRODUCTION

There are not many sports in which grip strength has a dominant influence on the outcome of a combat. A specific group are grappling sports. The grip in judo is a specific kind of interaction between the hand and the kimono as an object. In order to hold the object, a considerable isometric grip force must be exerted by the flexors of the hand, and therefore power and precision grips are common in functional activities (Buriánek, 2018). Thus, it would be very appropriate to include specific training of this key skill in judo training. Kumi-kata, or grip patterns, form the basis for all other actions in judo, as each move can be performed using a specific grip. Almost half of the time of each fighting segment in a combat is devoted to fighting for the grip, with this fight itself taking between 14 and 18 seconds (Štefanovský, 2015). If a competitor can use a significantly better grip than his opponent, he/she is at an advantage to execute the throwing technique and thus can win the combat. However, as highly complex athletes, judoka do not only use maximum grip strength to gain an advantage over their opponent. Explosive grip strength to quickly deflect an opponent and upper extremity endurance strength to maintain the necessary grip throughout the combat are also important components.

Despite all the knowledge about strength skills, there is no comprehensive, uniformly accepted classification of them. Thus, classification and terminology depends on the individual aspects applied, such as the type of muscle contraction, the type of muscle activity, or the nature of the movement (Choutka and Dovalil, 1991). In foreign authors we can encounter a division of strength skills depending on the speed of the movement performed. There is an inverse relationship between force and velocity represented by a curve, where we can observe that maximum force is exerted at high loads and, on the contrary, maximum velocity is generated at low loads. Thus, the goal of strength and conditioning training is to improve strength skills across the entire load spectrum, and therefore their speed component (Maestroni et al., 2020). A comprehensive overview is also added in their publication by Hohmann, Lames and Letzelter (2010). They emphasize clarification of what adaptive action is to be achieved in training as a fundamental principle in the development of strength skills.

At the beginning of the older school age

period, we develop strength skills in judo mainly by means of resistances and games and using various exercises with own weight (push-ups, jumps, pull-ups). The use of so-called power inputs is also appropriate. This is the interruption of a training activity in order to insert a specific short strengthening exercise (e.g. 10 push-ups and 10 squats). After the execution, the guided training resumes. Strengthening should be focused on large muscle groups in lower positions, avoiding possible overloading of the spine with added loads. It is highly advisable to perform the exercises in a varied and fun way and not to skip the final stretching, compensatory and relaxation exercises. The uneven onset of puberty places considerable demands on the proper individual development of strength skills in each exerciser. Kučera, Kolář, and Dylevský (2011) emphasize the training of strength development in older school-aged athletes primarily in the training of weight training technique, general strength training, and the development of speed-strength skills.

2. RESEARCH OBJECTIVE

The aim of the research investigation was to test the strength skills focused on the specific area of grip strength in a group of judokas of categories U12-U16, before and after the application of a targeted movement intervention.

In order to evaluate the changes achieved in strength skills tests due to the targeted movement intervention, we set two research questions. In the first, we would like to examine the change in hand dynamometry tests of the dominant and non-dominant hand, therefore we hypothesize that the improvement will be statistically more significant in the dominant hand than in the non-dominant hand. Furthermore, we also expect that boys will show statistically significant improvement in the tests after the application of the movement intervention compared to girls.

3. METHODOLOGY OF THE WORK

The research group consisted of a training group of judokas from Judoclub Plzeň (hereafter JC Plzeň). This group consists of judokas of categories U12, U14 and U16. All the subjects or their legal representatives voluntarily agreed to the processing of personal information, data and photographs for the purposes of this investigation.

Thus, the final total number of probands consisted of 37 judoka (30 boys and 7 girls) aged between 10 and 15 years. The judokas in this category mostly attend training units 3 times a week for 1.5 hours and participate mainly in regional or republican tournaments.

The research data collection of the initial testing took place during the transition period after the end of the judo season. Output testing took place after the completion of the preparatory period and the application of our targeted movement intervention.

Table 1: Basic anthropometric data about the research population (source: own)

	Number	Age	Height (cm)	Weight (kg)
Research group	37	12,89 (1,33)	164,41 (11,45)	56,26 (14,37)
boys	30	12,83 (1,32)	165,87 (12,03)	57,75 (14,67)
girls	7	13,14 (1,36)	158,14 (4,85)	49,91 (10,92)

Standard deviation (SD) is given in brackets.

For the purpose of the research, a test battery was created consisting of three motor tests aimed at measuring upper limb strength.

1. test item – dynamometry

The hand dynamometry test determines the short-term maximum static-force capacity of the hand flexors. In general, hand grip strength is one of the important methods of measuring health and physical fitness (Čuta and Vážná, 2021). For judo, this test is a very useful indicator as it tests the maximum grip strength, which is widely used and needed by judoka for a good grip on the kimono. The Grip D hand dynamometer T.K.K. 5401 was used for data collection. The grip of the dynamometer was calibrated, i.e. with the possibility of adjusting the grip with respect to the dimensions of the probands' hand finger lengths. Testing was performed by repeatedly gripping the hand twice with the left and twice with the right, with the higher result counted. For each measurement, the participant was asked to squeeze the dynamometer with maximum effort for 3 seconds. After each measurement, probands rested for at least two minutes to allow sufficient recovery of energy resources as recommended by Buriánek (2018). The measured results were converted to the basic force units, newton (hereafter N).

Testing was performed in two predefined positions simulating a judo grip of both upper limbs. The first position was standing with the dynamometer in the forearm (90°), the grip of the dynamometer was a neutral grip (see Figure 1, left). This position simulates the opponent's collar grip in judo. The second test position was again standing, but this time the arm was flexed at the elbow (flexion 90° at the elbow) and the dynamometer was grasped in supination (external rotation) 90° (see Figure 1 right). This position simulates in judo a grip on the opponent's sleeve, most often held just in supination (underhand grip).

Fig. 1: Two dynamometry test positions

Source: own

2nd test item - endurance in the pull-up
This test is used to determine the endurance static-strength skill of the arms and brachial plexus. In judo, isometric endurance strength is often used in combats to keep an opponent at a safe distance, or in ground fighting. Probands perform maximal endurance in the overhand bend (see Figure 2). The basic position is taken using a chair. After starting, the individual must hold the chin over the trapeze bar for as long as possible. The test ends when the chin drops below the level of the bar (Havel and Hnízdil, 2009). During testing, probands were verbally motivated, as this test is demanding on both strength and willpower qualities, which can be a limiting factor.

Fig. 2: Test position for maximum endurance on the trapeze bar

Source: own

3rd test item - rope climbing
The final motor test was a 5 m rope climb in 1 minute. This test focuses on another distinct component of strength skills, namely the largest dynamic explosive force output of the UL. The rope climb is also one of the motor tests used by the Czech Judo Federation coaches to make regional and national selections. For judo, this test simulates the pulling power of an opponent during matches and is therefore widely used. The starting position was standing with both hands on the rope. At the start instruction, probands climbed in pairs for one minute (see Figure 3). Due to the testing of probands of different categories, all were allowed to climb with the help of their feet to ensure equal conditions. Ropes climbed were counted in halves, marked with tape on the rope.

Fig. 3: Rope climb test for 1 minute

Source: own

Movement intervention

The applied movement intervention was part of the training sessions in the preparatory period of the judoka. A special training program was incorporated into the regular training sessions twice a week, which included exercises and posture training to improve the tested indicators in judoka. These exercises did not require any specific aids. Judoka strengthened with their own body weight or in weight-matched pairs. Examples of each exercise are shown in Figures 4-10. The initial part of the training consisted of various movement games to warm up the body. In this busy part, stretches and push-ups were also frequently included to engage the upper limbs. This was followed by a progressive warm-up using relaxation, dynamic stretching and activation strengthening exercises. In these exercises, attention was also focused on the muscles of the upper limb, especially the hand flexors.

The preparatory part included various gymnastic elements and judo falls. In this part of the training we also included various types of low locomotion over the mat using mainly dynamic explosive arm strength.

The main part of the training included exercises to develop judo skills, initially focusing on the coordination and speed component. We mainly trained techniques more related to the use of grip and arm work, e.g. used to deflect the opponent. Another component consisted of practicing various combat situations, which included the use of strengthening inputs. These inputs always included exercises to strengthen the whole body. Within the upper limbs, rope climbing, push-ups, or pull-ups were most often included. The practice of techniques in pairs was complemented by strengthening exercises in the form of various carries, pull-ups and push-ups. It was age-appropriate to include some competitive component for more motivation and fun. In addition,

exercises related to gripping the opponent were part of the training sessions. We worked on the correct opponent's grip, variations of these grips, or on the contrary, getting rid of the opponent's grip by snatching. Judokas also practice grip strength very well during these exercises.

After practicing techniques and combat situations in training sessions, followed randori, in other words practice combats. During the combats, specific grips were used, for example by both sleeves or kimono collars, or individuals alternated between defensive and offensive positions. Thus, long combats already created physically demanding conditions and with accumulating fatigue, strength endurance was developed. This ability was further developed in the upper limbs through interval endurance on the rope, ladders or trapeze.

The end of the training belonged mainly to calming down the body and various compensatory and stretching exercises. During the final stretching together we focused especially on the strengthened parts. It was important to stretch especially the finger flexors and the forearm muscles, which are most involved in gripping the kimono. Proper stretching and subsequent rest leads to muscle recovery and the possibility of progressive strengthening in subsequent workouts.

Photos of selected exercises included in own training intervention

Fig 4: Pull-ups over the mat with ankle hold

Source: own

Fig. 5: Pull-ups over the mat with holding onto the pant legs

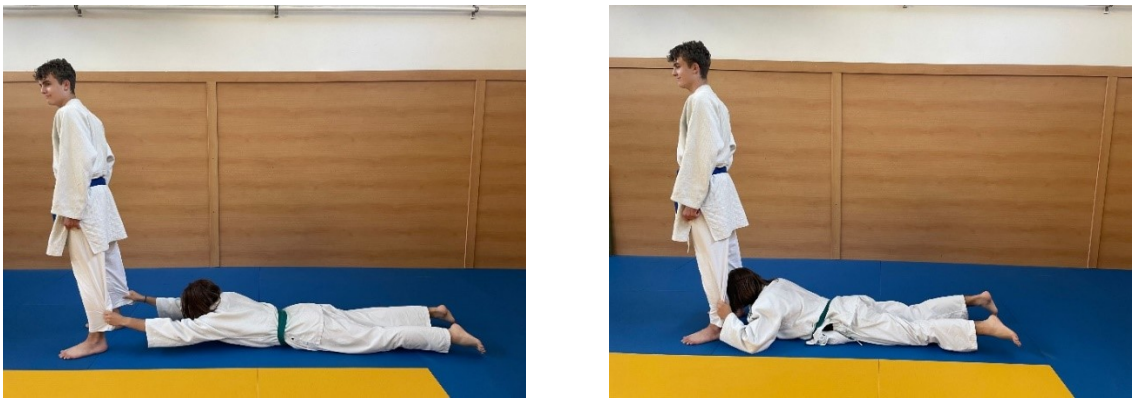

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Fig. 6: Pull-ups over the mat with holding the sleeves

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Fig. 7: Pull-ups with using the belt

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Fig. 8: Exercises using specific sleeve grips (left) or collar grips (right)

Source: own

Fig. 9: Different forms of crawling over the mat

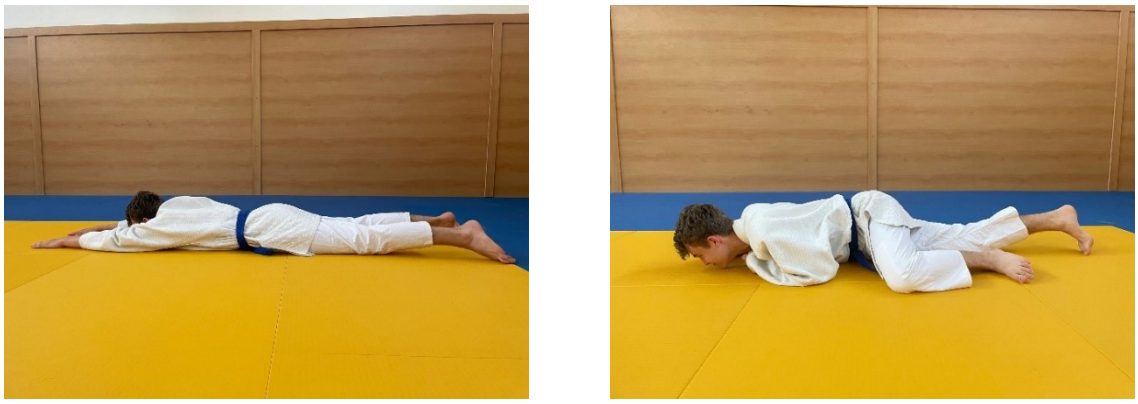

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Fig. 10: Exercises using a kimono on a trapeze bar– hanging, pull ups, or endurance in hanging

Source: own

Statistical data processing

Statistical evaluation of hypotheses was performed in RStudio (version 2023.03.0+386, R version 4.2.3).

Multiple statistical tests were used for efficient statistical decision making. The Shapiro-Wilk's auxiliary test was used to test the normality of the data. Paired tests were applied when comparing two dependent groups. If normality was rejected in at least one group, the non-parametric two-sample Wilcoxon test was used (Hendl, 2015).

The test of difference between three or more independent groups was applied to test for differences by three age categories. Fisher's exact test was used to evaluate the dependence of the data in the contingency table.

Research investigation

The first research question compared the change recorded in the hand dynamometry test between *the forearm position in extension and the 90-degree flexion position in supination.* We tested both in terms of absolute change recorded and, for control, relative change.

Graph 1: Scatter plot comparing the values from the two tests between the dominant arm (red) and the non-dominant arm (blue)

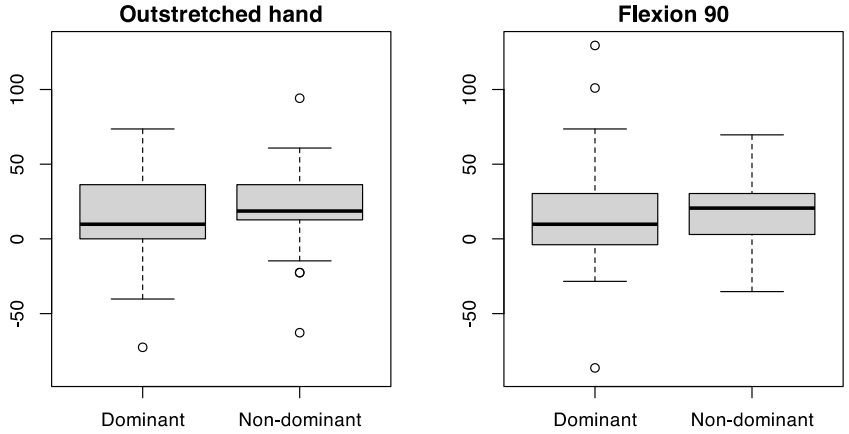
Source: own

Graph 1 provides a basic overview of the measured data. One point is shown for each proband, the coordinates of which are *the value of the first test and the value of the second test.* If the point lies above the dashed line, there has been an improvement; if it lies below the dashed line, there has been a downgrade. From the graph we can observe red points (dominant hand) and blue points (non-dominant hand). At first glance, there is no significant difference between these points, but a significant number of points are above the dashed line, indicating an upgrade in performance.

The testing section, where we assess whether the difference in changes is statistically significant, is presented in the last two columns of Table 2. The column labelled 'p_n value' contains the result of the Shapiro-Wilk normality test. Since we do not reject normality in either case, we subsequently use a paired t-test to compare the differences in changes on the dominant and on the non-dominant hands.

When evaluating the composite hypothesis (i.e., for the outstretched hand and Flexion 90 combined) using the Bonferroni correction, it is not possible to reject the null hypothesis of equal expected values of changes because none of the p-values is lower than 0.025.

Graph 2: Boxplots of changes achieved between dominant and non-dominant hands



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Tab. 2: Sample characteristics of changes by dominance and results of testing for differences.

Test	Characteristics of changes						p_n value	p value
	Count	Mean	Median	Minimum	Maximum	SD		
Hand outstretched								
Dominant	37	14.6	9.8	–72.6	73.6	28.6	0.257	0.043*
Non-dominant	37	22.3	18.6	–62.8	94.2	27.7		
Flex 90								
Dominant	37	15.9	9.8	–86.3	129.5	38.3	0.416	0.957
Non-dominant	37	16.3	20.6	–35.3	69.7	26.7		

Note: In the column labelled "p_n value," the result of the normality test for the data is provided. Normality was not rejected in either case, so the "p value" column contains the result of the paired t-test.

Another perspective on the obtained results is in terms of relative change. The data and results of statistical tests are presented in Table 3.

From the results in the column labelled 'p value', it is evident that in separate hypothesis testing, we could reject the null hypothesis for the outstretched hand and accept the alternative that the medians of relative differences on the dominant and on the non-dominant hands are different. However, in this case, a higher relative increase (8.1%) is observed in the non-dominant hand compared to the dominant hand (4.7%).

When evaluating the composite hypothesis (i.e., for the outstretched hand and Flexion 90 combined) with the use of Bonferroni correction, we could reject the null hypothesis of equality and accept the alternative that relative changes differ between the dominant and non-dominant hands (at least one p-value is lower than 0.025).

Table 3: Sample characteristics of relative changes by dominance and results of testing for differences.

Test	Characteristics of changes						p_n value	p value
	Count	Mean	Median	Minimum	Maximum	SD		
Hand outstretched								
Dominant	37	4.7 %	3.7 %	–25.3 %	23.6 %	9.1 %	0.011*	0.020*
Non-dominant	37	8.1 %	7.7 %	–24.0 %	45.1 %	10.8 %		
Flex 90								
Dominant	37	5.1 %	3.1 %	–32.1 %	37.0 %	12.5 %	0.818	0.701
Non-dominant	37	5.9 %	6.0 %	–12.1 %	31.8 %	10.3 %		

Note: In the column labelled "p_n value," the result of the normality test for the data is provided. For the outstretched hand, normality is rejected, and the "p value" column contains the result of the paired Wilcoxon test. For flexion, the result of the paired t-test is provided.

The hypothesis that the change in the dominant hand would be statistically significant compared to the non-dominant hand was not supported in either view, and so the hypothesis that the dominant hand would show a greater improvement than the non-dominant hand could not be supported. Conversely, a statistically significant change was shown for the outstretched hand test in favour of the non-dominant hand, where a more significant relative improvement was noted. These results may indicate that the subjects had a naturally stronger dominant UL, as evidenced by the resulting mean test value of 335 N versus 317.5 N on the non-dominant side. Thus, the resulting improvement was more pronounced on the non-dominant UL side in both the flexion 90 test and especially the outstretched hand test. For the last test (rope 1 min) when comparing groups, we will convert values into categories: downgrade, stagnation, and upgrade. This approach helps us avoid issues with expressing percentages, especially when we cannot calculate them for zero initial values. An overview of the values is provided in Table 4. To test whether there is a statistically significant association between age groups and categories among the divided groups, we used Fisher's exact test. The resulting p-value is 0.891, and we cannot reject the hypothesis of independence between age groups and categories.

Table 4: Categories of change for the rope test (1 min) by age group.

Group	Number in categories			Percentage of		
	Down grade	Stagnation	Upgrade	Down grade	Stagnation	Upgrade
10–11 years	0	1	2	0 %	33 %	67 %
12–13 years	1	6	14	5 %	29 %	67 %
14–15 years	1	2	10	8 %	15 %	77 %

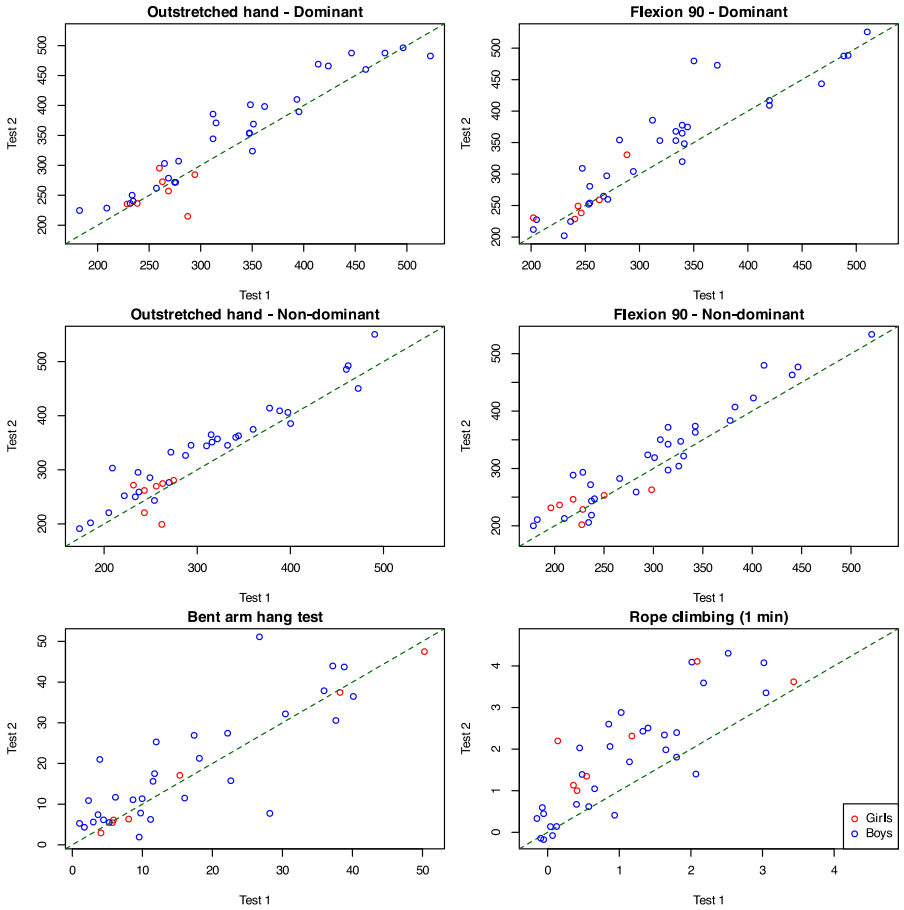
4. DISCUSSION

We found differences in the results of only two manual dynamometry tests - *hand outstretched* on the non-dominant side and *flexion 90* on the non-dominant side. Since in the post-hoc tests performed in these two cases the difference was always identified only between the 10-11 years category and the others, and we have only three probands in the 10-11 years category, we cannot give too much weight to the conclusions. However, this finding can serve for further observation with multiple groups and can be the basis for the development of maximal grip strength already in this age group.

We tested the results leading to the second research question from two perspectives. In the first, we focused on the difference test. Here, however, the results could be influenced by the fact that the initial values of the two groups often differ. So in the second part we compared the relative difference, i.e. by how much the initial value changed in both groups.

Graph 3 serves as a basic overview of the data and contains one point for each proband, the coordinates of which are *the value of the first test and the value of the second* test. If the point lies above the dashed line, there has been an improvement; if it lies below, there has been a deterioration. The graph does not suggest that the red points (girls) and the blue points (boys) differ in any significant way in the degree of improvement.

Graph 3: Scatter plot comparing values from the two tests between girls (red) and boys (blue)



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While the results suggest that there could be statistically significant differences between boys and girls, since there were only seven representatives in the girls' group, the statistical tests are not very powerful and could only detect a significant difference. In the future, it would be advisable to focus on obtaining more data from the girls and to perform the testing again, where especially the differences between the girls' and boys' results in the bending endurance test indicate interesting values for further research.

5. CONCLUSION

In the judo environment we lack work dedicated to the development of specific grip strength, which is so important in this sport. In judo as a combat sport there are still more boys than girls, which has led to a slight bias in the results and certainly further re-testing with a larger group of girls would be appropriate. Overall, after completing the training program, there was an average improvement for boys in all tested indicators. In the group of girls, on the other hand, there was a slight downgrade in three tests, which indicates to us different parameters and strength development compared to boys already in these age categories.

When comparing the performance of the dominant and non-dominant hand in the hand dynamometry tests, we observed a statistically significant change in the outstretched hand test in favour of the non-dominant hand. However, this

statistical significance has not been demonstrated by other studies such as Štefanovský (2015); Ache Dias et al. (2012); or Štefanovský, Durmis and Kraček (2018).

Moreover, Ache Dias et al. (2012) also found no significant differences in the hand dynamometry test between highly trained Brazilian judokas and non-judokas. However, the effect of judo training on the level of handshake fatigue was demonstrated.

Štefanovský (2015) focused his research on comparing the maximum grip strength of the dominant hand when testing 11-year-old boys training taekwondo (176.6 N), judo (189.3 N) and karate (200.1 N). Thus, the karate group obtained the highest mean values from this study. However, in comparison with our results for the U12 age group, the judokas tested by us clearly dominate, having improved their average value of 257.3 N for the outstretched hand test and even 263.9 N for flexion 90.

In the 1-minute rope climb test we can see the limiting factor in again the proband's weight and gravitational force, but also in the use of the legs in the climbing technique. Thus, individuals who could also use their feet better to assist in climbing were more likely to achieve a better result. However, without the necessary upper limb strength, even this skill is not enough. Of the 37 probands, a total of 26 individuals, regardless of age or gender, were able to improve since initial testing, and only 2 individuals have gotten worse over the preparation period.

A specific focus on grip strength in judoka could also be a benefit of this research investigation. The issue of grip strength has not received much attention in the theoretical and practical aspects of contemporary judo, although it is one of the fundamental aspects of performance.

The results can be used not only in the grappling setting for further extension and validation of significance with the involvement of a much larger number of probands. We believe that the attached movement intervention will also serve as inspiration for the development of upper limb grip strength not only for judo coaches and will provide some impetus for more research and testing related to grip technique and strength.

6. LITERATURE

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CONTACTS

Mgr. Věra Knappová, PhD.

Centre of Physical Education and Sport
Faculty of Education
University of West Bohemia in Pilsen
Czech Republic
e-mail: knappova@ktv.zcu.cz