RELATIONS BETWEEN SOME TYPES OF FOREARM STRENGTH IN KINESIOLOGY STUDENTS

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topologic region is underhand grip chin-up (CHINUP). The problem occurs due to the lack of tests estimating maximum, static and repetitive forearm strength, the left one and the right one separately. The authors’ opinion is that forearm strength is of crucial importance in some sports. One of those sports is judo, where static and repetitive strength of the arm and shoulder area are very important for fight success (Franchini, Del Vecchio, Matsushigue, & Artioli, 2011). During a fight, judo athlete should develop maximum dynamometric fist power, so as to prevent the opponent escaping the grip (guard). The authors’ area of interest is judo research. Therefore, this paper served as a pilot research, with the purpose of aiding future measuring of judo athletes. The aim of this research was to determine the relations between maximum, static and repetitive strength of the left and the right forearm separately, in kinesiology students. The partial aim of the research was to determine some metric characteristics of the applied evaluation tests measuring the listed aspects of strength.
METHODS

The subject sample consisted of 10 first year kinesiology students in Split, whose average age was 19.3±1.2 years. Although the sample was convenient, all the examinees had been involved, or still have been involved in some sport training process during the conducted research. All examinees were healthy and free of any aberrative signs during the measuring. The group of variables was made up of manifested forearm strength evaluation tests. The measuring was conducted on the right and left forearm. Two tests were conducted, one evaluating maximum static and repetitive strength of the right and one of the left forearm. Variables for assessing maximum strength: maximum right forearm strength evaluation test – maximum dynamometric right hand force (MDFR), maximum left forearm strength evaluation test – maximum dynamometric left hand force (MDFL). Variables for evaluation of static strength: right forearm static strength evaluation test – extended right arm high endurance (EAHER), left forearm static strength evaluation test – extended left arm high endurance (EAHEL). Variables for repetitive strength evaluation: right forearm repetitive strength evaluation test – maximum number of right hand finger flexion on the grip machine (MNFG), left forearm repetitive strength evaluation test – maximum number of left hand finger flexion on the grip machine (MNFL). Also, a morphological variable of body mass (BM) has been calculated. With the purpose of achieving the main aim of the research - the relations between the three listed aspects of strength - the listed variables were transformed into relative values, with the test values divided by the body mass. According to this, the following variables were gained: MDFR(KG/kg), EAHER(S/kg), MNFG (REP/kg) for the right and MDFL(KG/kg), EAHEL(S/kg), MNFG(REP/kg) for the left forearm, where KG is power of the grip, S stands for seconds, that is, time, and REP denotes the number of repetitions.

Description of the experimental procedure: all the examinees were warned to avoid physical strain one day prior to the measuring, especially the activities involving fist (hand) activities, so as to avoid accumulation of fatigue in that body part. The measuring was conducted in the „Split“ judo club, where „Judo“ kinesiology classes are held. The body mass was measured three times, using a digital scale, the examinees were barefoot in sport judo equipment and kimono, and the result was read off with the tenth of a kilogram precision. The results of the (BM) morphological variable were condensed by calculation of the three measuring means. A test of maximum dynamometric force (MDF) was used in evaluation of maximum forearm strength, using the Takei A5401 Japanese manufacturer digital dynamometer. Every examinee had a task of generating as much force as possible by squeezing right and left arm, separately. All three values were read off in kilograms, and the maximum value of the attempts was used in analysis. The metric characteristics of the digital dynamometer used in this research will not be analysed, because it is an instrument of high precision, with wide range of appliance in clinical and sports research. Extended arm endurance test was performed to assess static forearm strength (IV). The examinees had a task of holding on, as long as possible, with their flexed fist on a metal bar. The examiner, using a hand stopwatch, measured the time from the beginning of the test, until the end, when the examinee touched the ground. The test was conducted using the left and the right arm. The values were read off in seconds. A maximum number of flexion on the grip machine test (MNFG) was conducted in the evaluation of the repetitive forearm strength. A steel Heavygrip 200 instrument was used in measuring the maximum number of fist fingers flexion. The test considered correct every repetition where an examinee would press the instrument all the way to the end. The examiner would stand next to the examinee and count the correct repetitions. The test was conducted on the right and left hand. Due to the demanding nature of the tests (EAHE) and (MNFG), only one instance of measuring was conducted. The protocol of the test performance was the following: after determining body mass, every examinee took the maximum dynamometric force test (MDF). When all the examinees took the test, the following test was performed - extended arm high endurance (EAHE), and finally - maximum number of hand finger flexion on the grip machine (MNFG). In order to avoid the fatigue of the examinees’ forearm muscles, the examinees took one test at a time, with minimum of 30 minutes of recovery between the attempts. The following descriptive statistic parameters were calculated: mean (M), minimum (MIN) and maximum result (MAX), standard
deviation (SD) and Kolmogorov – Smirnov test (K-S) of all the variables for estimation of the manifested aspects of strength and the morphological variables – body mass in kinesiology students. To determine the metric characteristics of the analysed variables of manifested aspects of strength estimation, the following was calculated: the reliability of the measuring instruments was analysed by applying the correlation analysis between two instances of measuring (so called TEST – RETEST METHOD), the sensibility of the measuring instruments was analysed with distribution normality test, measuring instruments was analysed using a dependent samples T-test. The Kolmogorov – Smirnov distribution normality test, the homogeneity of measuring instruments was analysed using a dependent samples T-test. The Pearson correlation coefficient was calculated to determine the relations between the maximum, static and repetitive strength, separately for the right and the left forearm in kinesiology students.

RESULTS AND DISCUSSION

Table 1 shows the results of the descriptive statistic parameters: mean (M), minimum (MIN) and maximum result (MAX), standard deviation (SD) and Kolmogorov – Smirnov test (K-S) of the variables assessing maximum, static and repetitive strength of right and left forearm, and of one morphological variable – body mass. Results of the BM variable show that the lightest examinee weighed 75.6 kg, whereas the heaviest examinee weighed 102.7 kg. The MDF test (maximum strength estimation variable) showed the average results of 51.2 kg for the right and 50.2 kg for the left forearm. In comparison, in the research (Gunther, Burger, Rickert, Crispin, & Schulz, 2008) conducted on healthy adults, the average values were 49 kg for right forearm and 47 kg for the left one. Such result is no surprise, since the examinees were athletes. Also, it should be mentioned that in this test the right forearm of the examinees is stronger than the left one. Further on, static strength evaluation variables, i.e., isometric forearm muscle contractions, show that the right arm is dominant over the left one. The average result of the right arm was 18.1 s while the result for the left one was 14.9 s. The last test, the one with repetitive forearm strength evaluation, shows a great range of results. The minimum result for the right forearm was 2 repetitions, and the maximum 25, while, on the other hand, the minimum result for the left forearm was 1 repetition, and the maximum 24. The values of K-S test show normal distribution of all the variables, indicating the sensitivity of the tests, i.e., a successful differentiation of the examinees according to the subject of measure.

Table 1 Descriptive statistic parameters: mean (M), minimum (MIN) and maximum result (MAX), standard deviation (SD) and Kolmogorov – Smirnov test (K-S)

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>MIN</th>
<th>MAX</th>
<th>SD</th>
<th>KS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM</td>
<td>84.9</td>
<td>75.6</td>
<td>102.7</td>
<td>9.10</td>
<td>p &gt; .20</td>
</tr>
<tr>
<td>MDFR</td>
<td>51.2</td>
<td>38.4</td>
<td>60.3</td>
<td>6.74</td>
<td>p &gt; .20</td>
</tr>
<tr>
<td>MDFL</td>
<td>50.2</td>
<td>42.2</td>
<td>55.6</td>
<td>5.32</td>
<td>p &gt; .20</td>
</tr>
<tr>
<td>EAHER</td>
<td>18.1</td>
<td>7.2</td>
<td>39.1</td>
<td>8.65</td>
<td>p &gt; .20</td>
</tr>
<tr>
<td>EAHEL</td>
<td>14.9</td>
<td>5.8</td>
<td>31.2</td>
<td>7.98</td>
<td>p &gt; .20</td>
</tr>
<tr>
<td>MNFGRT</td>
<td>13.4</td>
<td>2.0</td>
<td>25.0</td>
<td>8.79</td>
<td>p &gt; .20</td>
</tr>
<tr>
<td>MNFGLL</td>
<td>9.2</td>
<td>1.0</td>
<td>24.0</td>
<td>7.51</td>
<td>p &gt; .20</td>
</tr>
</tbody>
</table>

As shown in table 2, there was a medium high correlation between the test and retest in all the variables. It can be concluded that the measuring instruments, i.e., the tests, are reliable for left and right forearm. Right and left forearm static strength evaluation variable shows the identical correlation coefficient value (r=0.81). On the other side, the value of repetitive strength evaluation variables correlation coefficient is 0.94 for the right and 0.80 for the left forearm. Observing all the tests in total, the MNFGTR test is the most reliable. One of the possible explanations of this high correlation is that the examinees’ right forearm, or arm, is stronger than the left one, as shown in Table 3.

Table 2 Correlation between two instances of measuring of left and right forearm static and repetitive strength tests (TEST-RETEST)

<table>
<thead>
<tr>
<th>TEST - RETEST</th>
<th>r</th>
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<tbody>
<tr>
<td>EAHER TEST – EAHER RETEST</td>
<td>0.81</td>
</tr>
<tr>
<td>EAHEL TEST – EAHEL RETEST</td>
<td>0.81</td>
</tr>
<tr>
<td>MNFGR TEST – MNFGR RETEST</td>
<td>0.94</td>
</tr>
<tr>
<td>MNFG LR TEST – MNFG LR RETEST</td>
<td>0.80</td>
</tr>
</tbody>
</table>

r- coefficient of correlation
The homogeneity of the measuring instruments was checked by the dependent samples T-test (Table 3). The results obtained by test and retest were compared. The T-test EAHER (t=1.74 and p=0.12) and EAHEL (t=0.56 and p=0.59) variables showed no statistically significant differences between the test and retest, or, there is no result shift towards left or right. It can be concluded that the applied test had good homogeneity for the left and the right forearm. On the other hand, the T-test MNFGR and MNFGL variables show statistically significant differences (p=0.01), and the tests lack satisfying homogeneity.

The fact that repetitive strength has been manifested in a different manner than maximum and static strength. The muscle performing the movement was constantly contracting and relaxing - partially resting. The basic limit was a part of the excitation signal, which, after some time, was not as strong as it had been at the beginning, so the movement (in this case fist squeezings) was becoming harder to perform (Sekulić and Metiškoš, 2007). Further insight into the results showed that there was a significant correlation between the repetitive and static strength on the right forearm (r=0.68), which was not the case on the left one (r=0.07). Some authors tried to extrapolate the repetitive strength from the static (Sale and Norman, 1982; Young and Bilby, 1993). A question arises: Can static strength be a successful predictor of the repetitive strength? The researchers who dealt with this problem found conflicting results, some of them showing high correlations, some of them showing relatively low correlations (Ignjatović et al., 2009).

Tables 4 and 5 show correlation coefficients of relative values of the variables assessing maximum, static and repetitive strength of the right and the left forearm. The results lead to the conclusion that there was a statistically significant correlation between the maximum and static strength of the right (r=0.69) and the maximum and static strength of the left forearm (r=0.82). The muscles engaged in both tests were constantly contracted, so the result was not surprising. Further on, there was no statistically significant correlation between the maximum and repetitive strength of the right or the left forearm (right forearm r=0.56, left forearm r=0.36), which was not expected. One of the possible explanations for the lack of correlation was the presence of a repeated measurement error.
larger sample, especially the population of athletes whose forearm strength is a key to success, such as judo athletes.

**CONCLUSION**

The aim of this research was to determine the relations between maximum, static and repetitive strength, separately for the right and left forearm, as well as to determine some metric characteristics of the applied particularized aspects of strength evaluation tests. The results of descriptive statistics showed that students’ right forearm was stronger than the left one in all the aspects of manifested strength. Static and repetitive strength evaluation tests had good reliability and sensitivity, but they lacked homogeneity. The correlation analysis showed correlation between the right and left forearm maximum and static strength. There was no correlation between maximum and repetitive strength of both forearms. Right forearm showed correlation between repetitive and static strength, which was not the case for the left one. The lack of research dealing with similar problems made the result analysis much more difficult. More tests should be conducted on a larger number of samples such as judo athletes, whose aspects of strength, analyzed in this research, are of great importance.

**REFERENCE**


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ПОВРЗАНОСТА НА НЕКОИ ВИДОВИ НА СИЛИНА НА ПОДЛАКТИЦАТА КАЈ СТУДЕНТИТЕ ПО КИНЕЗИОЛОГИЈА

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Абстракт
Цел на ова истражување беше да се утврди поврзаноста на максималната, статичката и репетитивната сила, посебно на десната и левата подлактица кај студентите по кинезиологија. Парцијална цел на истражувањето беше да се утврдат и некои мерни карактеристики на применетите тестови за проценка на наведените видови на силина. Од добиените резултати на дескриптивната статистика може да се заклучи дека кај студентите десната подлактица е посилна од левата во сите видови на манифестирање на силината. Основно, тестовите за проценување на статичката и репетитивна силина имаат добри валидност и осетливост, но не и хомогеност. Со корелационата анализа утврдена е поврзаност на максималната статичка снага на правата и левата подлактица. Нема поврзаност мегу максималната и репетитивната силина кај двете подлактици. На десната подлактица добиена е поврзаност на репетитивната и статичката силина, што не е случај кај левата. Недостатокот од истражувањето на слична проблематика во голема мерка го отежна интерпретирањето на резултатите. Тестовите треба да се проверат на поголем примерок како јудисти, кај кои анализираните видови на силина во ова истражување е многу значајна.

Ключни зборови: поврзаност, максимална, статичка и репетитивна сила