The effect of muscle strength on the capacity of coordination in handball

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Abstract

The relationship between muscle strength and coordination capacity was examined at 17 handball players aged between 16-18 years old (M = 17.06, SD = 0.827). Strength indices were calculated by reporting the measured values to body weight. “The muscle strain differentiation test of hands” was used for the neuromuscular coordination capacity and the “Pendulum-throw-target” test for the throwing accuracy. The paper notes that muscle strength, being below the optimal values, does not significantly influence the coordination capacity (CI = 95%). During this period, it is important to intensify the intramuscular coordination training, due to the qualitative aging of the SNC.

Keywords: handball, isometric muscle strength, dynamometry, capacity of coordination.

1. Introduction

Researches on efficiently training the athletes by improving the capacity of coordination within the individual training are of great interest. The individualization of training for handball players is necessary due to the existent differences between tactical and technical content specific to the different game positions, but also to the high degree of difficulty of the technical execution (Baștiurea, 2005; Rizescu, Ghervan, Baștiurea, & Georgescu, 2011). In modern handball, athletes can play almost on any game position and so, they need more coordination to handle the technical and tactical actions specific to the game position that they play in, at a given time. Adapting to the

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change of a game position should be fast and done by selecting and executing a quick and appropriate response to a
stimulus via an efferent way, from the nerve centers to certain effectors (Mihăilă, 2011; Cicma & Mereuță, 2012).

Reijo, Caroline, Pavoo, & Vesa (2009) demonstrated that the complex process of fast adaptation of the entire
body to the requirements of the game has on its basis a constant feedback between motor skills, control and level of
fatigue. Bompa (2001) presents coordination as a complex capacity correlated with speed, strength, endurance and
mobility. From a physiological point of view, in the case of human beings, coordination is determined by the quality
of nerve processes, by genetic and environmental factors. Baștuirea (2007) shows that the level of coordination
represents the ability to execute movements having different degrees of difficulty, quickness, with great accuracy
and high efficiency in accordance with the specific objectives of the training. Of all the motor skills, muscle strength
affects execution speed, endurance and coordinative abilities (Peper, Betteco, Harjo, & Peter, 2008). Force
development in parallel with the repeated practice of one skill or of one technical element lead to the adjustment of
the fundamental nervous processes of excitation and inhibition, the result being a series of fine motor skills, reliable,
efficient and well coordinated (Bompa, 2001). In fact, the adjustment of these processes results into an efficient
“agonistic-antagonistic” co-activation (Cholewicki, Panjabi, & Khachatryan, 1997). The control capacity of time,
space and strength parameters of movement increases actively from 6-7 years to 10-12 years. These skills decrease
over time, both with adolescent girls and boys. At the end of puberty this capacity increases again until 17-18 years
old and it further stabilizes. A similar dynamic age is characteristic for the natural development of voluntary
loosening (free) capacity of the muscles (Șicu, 2006; Moisescu, 2011). The loosening capacity and the voluntary
muscle contraction capacity have on their basis a neuromuscular control (Madeleine, Mathiassen, & Arendt-Nielsen,
2008). Latash, Scholz, & Schöner (2002) demonstrate the importance of sensory information in the adaptation of the
workforce. The idea is supported by Slifkin, Vaillancourt, & Newell (2000) who show that visual feedback adjusts
the power output. Other authors have carried out a growth chart for children, based on a model of the fingers
strength (Visnapuu & Jurimae, 2007) and Maslovat, Lam, Brunke, Chua, & Franks (2008) demonstrated the effect
of the muscle strength on the cyclic motion of the arms. In sports games, correlations between anthropometric
indices and palmar force in handball and basketball players were studied (Molenar, Ruud, Sten, Steven, & Henk,
2011), and the conclusion was that those with higher weight and larger finger length have a superior force.
Significant correlations between anthropometric and force parameters were also found by other authors (Hager-Ross
& Rosblad, 2002; Sartorio, La Fortuna, Trecate, 2002; Stan, 2009). The subjects studied in this paper were aged
between 16 and 18 years old, so, according to the authors quoted above, the subjects are in the second period of
increasing their capacity of coordination and during the muscle strength growth. The purpose of this study is to find
out how athletes manage to combine the two qualities, both being during their optimal development period. Another
purpose is to find out, based on the conclusions drawn, whether some recommendations useful for the future sport
activity can be provided. We have hypothesized that coordination test results are influenced by the values of muscle
strength indices. However, we have noticed that the level of strength indices calculated for this team’s athletes falls
within the normal values.

2. Methods

2.1 Subjects

To study the relationship between muscle strength and the capacity of coordination in the handball game, a young
team of handball players aged between 16 and 18 years old was examined (M = 17.06, SD = 0.827). It is important
to mention that all athletes were in a good state of health so as to perform the tests correctly and with maximum
efficiency. The study was conducted over a two-day period. On the first day, coordination tests were carried out and
on the second day, the force measurement tests were performed.

2.2. Testing procedure

In Table 1, abbreviations for the variables used in the paper will be presented.
Table 1 the abbreviation of variables used

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMI</td>
<td>The flexor muscle strength of the skilful arm</td>
<td>IFSL</td>
<td>Lumbar segmental strength index</td>
</tr>
<tr>
<td>FMN</td>
<td>The flexor muscle strength of the unskilful arm</td>
<td>IFG</td>
<td>Global strength index</td>
</tr>
<tr>
<td>FSC</td>
<td>The muscle strength of the scapular region</td>
<td>DIMM FMI</td>
<td>Muscle tension differentiation of the skilful arm</td>
</tr>
<tr>
<td>FL</td>
<td>The muscle strength of the lumbar region</td>
<td>DIMM FMN</td>
<td>Muscle tension differentiation of the unskilful arm</td>
</tr>
<tr>
<td>IFSM</td>
<td>Segmental strength index of the arms</td>
<td>PART</td>
<td>Accuracy of throwing to the target</td>
</tr>
<tr>
<td>IFSS</td>
<td>Scapular segmental strength index</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2.1. Testing the flexor muscle strength of the hands (FMI and FMN)

In orthostatic position, the subject holds the palmar dynamometer in his hand in the extension of the forearm and flexes with maximum power, without swinging the body or the arm lying on its side. The dynamometer must be adjusted to the size of the palm of each group of subjects to increase measurement accuracy. Two test runs are executed and the best value is retained (Cordun, 2009). The values below are given in kilogram force for adult subjects (Table 2).

Table 2 Values of the palmar guidance flexion test with adult subjects

<table>
<thead>
<tr>
<th>Result</th>
<th>Excellent</th>
<th>Very good</th>
<th>Above average</th>
<th>Average</th>
<th>Below average</th>
<th>Low</th>
<th>Very low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>&gt; 38</td>
<td>34-38</td>
<td>30-34</td>
<td>26-30</td>
<td>22-26</td>
<td>20-22</td>
<td>&lt; 20</td>
</tr>
<tr>
<td>Male</td>
<td>&gt; 64</td>
<td>56-64</td>
<td>52-56</td>
<td>48-52</td>
<td>44-48</td>
<td>40-44</td>
<td>&lt; 40</td>
</tr>
</tbody>
</table>

2.2.2. Testing the scapular muscle strength (FSC)

Measuring is done using a device consisting of two handles that have a dynamometer attached between them. Through its construction, the device converts the force measured when the handles are pulled in pressure force exerted on the dynamometer. For measurement purpose, in orthostatic position, the subject will grip with his hands the handles of the device, will stabilize his forearms horizontally and will pull the handles with all his strength. Two test runs are executed and the best value is retained (Cordun, 2009).

2.2.3. Testing the lumbar muscle strength (FL)

The measurement is done using a device consisting of a handle provided with a chain and a plate which has a hook attached to its center. The dynamometer is interposing between them. For measurement purpose, the subject places his feet on the board, on both sides of the hook and bends his torso until the hands that grabbed the handle reach the level of the knees. The length of the chain is adjusted, so that the subject has the spine as straight as possible, the knees are in full extension and the handle is positioned at the level of the knees. For measuring, the subject will pull the handle, by contracting the extensor muscles of the spine. Two test runs are executed and the best value is retained (Cordun, 2009).

2.2.4. Calculation of muscle strength indices

In Table 3, the terms used for strength and the calculation of strength indices are marked down (Cordun, 2009).

Table 3 Terms used for strength and the calculation of the strength indices

<table>
<thead>
<tr>
<th>Calculated strength indices</th>
<th>Abbreviations</th>
<th>Formulas</th>
<th>Optimal values</th>
</tr>
</thead>
</table>
| Segmental strength index of the hands | IFSM | $\text{IFSM} = \frac{(\text{FMI} + \text{FMN})}{2} / G \times 100$ | Females = 50% of the body weight  
Males = 60-70% of the body weight |
| Scapular segmental strength index | IFSS | $\text{IFSS} = \frac{(\text{FSC})}{G} \times 100$ | Females = 50% of the body weight  
Males = 75% of the body weight |
| Lumbar segmental strength index | IFSL | $\text{IFSL} = \frac{(\text{FL})}{G} \times 100$ | Females = 120-150% in regard to body weight  
Males = 180-200% in regard to body weight  
IFG = $\frac{(\text{FMI} + \text{FMN} + \text{FSC} + \text{FL})}{4} / G \times 100$ |
| Global strength index       | IFG           | $\text{IFG} = \frac{(\text{FMI} + \text{FMN} + \text{FSC} + \text{FL})}{4} / G \times 100$ | Normal values are between 0.7-1. In strength sports it strives to 1. |
2.2.5. Testing the muscle tension differentiation of the hand

In orthostatic position, the subject holds the palmar dynamometer in his hand in the extension of the forearm and flexes with maximum power, without swinging the body or the arm lying on its side. He/she retains the tightness of his/her grip and afterwards, he executes the same thing, but with his/her eyes closed. This time, the grip should reach half of the initial value, through voluntary neuromuscular control. The assessment of the outcome consists in analyzing whether the value of the second grip is above or below half of the initial value (Полиевский, 1984; Baștiurea, 2005; chicu, 2006).

2.2.6. Testing the coordination of throwing to the target (the “Pendulum-throw-target”)

Materials: gymnastics circle (diameter = 80cm), 6 tennis balls, string, meter. A pendulum is made of a string (60cm) and a gymnastics circle is fixed on the wall. The athlete stands in the initial-final position at 3 meters away from the wall (Figure 1). The professor raises the pendulum horizontally and he releases it, giving it the opportunity to swing in both directions. When the pendulum is moving in the opposite direction, the athlete will throw the ball in the circle. The results are judged by the precision of the throws: the edge of the circle - 1 point; the interior of the circle - 2 points. Before trying the control throw, the athlete is allowed to perform a sample throw (Лях, 1989; Baștiurea, 2005; chicu, 2006).

![Fig. 1 the “Pendulum-throw-target”](image)

2.3. Data analysis

The collected data was processed using SPSS v.20 program for Windows. A Pearson correlation was conducted to examine the relationship between the analyzed variables and a linear regression to determine the variables of the performance prediction. The confidence coefficient for the statistical significance is of 95%. The accuracy level of the prediction will be highlighted through several Scatter charts.

3. Results

Table 4 lists all the test results described in chapter two, but also the results of strength indices calculations described in the same chapter. The following aspects can be observed: only four of the 17 athletes (subject 1, 2, 6 and 17) have strength values above the normal requirements in all tests; at IFSS, none of the subjects is within the standard; at IFSL there can be found the highest frequency of those who fit into standard or have surpassed it (16 subjects); at PART test, there are three athletes having obtained a maximum score. Although IFG is within the normal limits (with one exception), it should be noted that body weight plays an important role in the calculation of this index.
After statistical processing, the following essential data resulted, for regression analysis, regarding the seven pairs of variables (Table 5). Three pairs of variables with a coefficient of visible association can be highlighted. FMN with DIMM, where \( r = 0.43\% \) (Figure 2); pair IMF with DIMM, where \( r = 0.34\% \) (Figure 3) and the pair IFSS - PART, where \( r = 0.26\% \) (Figure 3). The weakest correlation is observed in the case of the pair of variables DIMM FMI - PART (0.02%), with a flow chart shown in Figure 4. Regardless of the identified values, the correlation is positive. The regression coefficient has the highest value at FMN (B = 0.57) and with a standard error of 0.30. In these conditions, for each 1-point increase of FMN, DIMM increases by 0.57.

### Table 5 Regression analysis

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>95.0% Confidence Interval for B</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>St. Error</td>
<td>Beta</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>DIMM</td>
<td>14.073</td>
<td>11.239</td>
<td>-</td>
<td>-9.882</td>
<td>38.028</td>
</tr>
<tr>
<td>FMI</td>
<td>0.343</td>
<td>0.238</td>
<td>0.349</td>
<td>-0.164</td>
<td>0.850</td>
</tr>
<tr>
<td>Constant</td>
<td>1.510</td>
<td>14.048</td>
<td>-</td>
<td>-28.433</td>
<td>31.454</td>
</tr>
<tr>
<td>FMN</td>
<td>0.578</td>
<td>0.306</td>
<td>0.438</td>
<td>-0.074</td>
<td>1.230</td>
</tr>
<tr>
<td>PART</td>
<td>9.374</td>
<td>1.992</td>
<td>-</td>
<td>5.128</td>
<td>13.621</td>
</tr>
<tr>
<td>DIMM FMI</td>
<td>0.007</td>
<td>0.064</td>
<td>0.029</td>
<td>-0.130</td>
<td>0.144</td>
</tr>
<tr>
<td>Constant</td>
<td>7.514</td>
<td>3.265</td>
<td>-</td>
<td>0.554</td>
<td>14.474</td>
</tr>
<tr>
<td>IFSM</td>
<td>0.035</td>
<td>0.054</td>
<td>0.163</td>
<td>-0.080</td>
<td>0.149</td>
</tr>
<tr>
<td>Constant</td>
<td>6.041</td>
<td>3.347</td>
<td>-</td>
<td>-1.093</td>
<td>13.176</td>
</tr>
<tr>
<td>IFSS</td>
<td>0.073</td>
<td>0.068</td>
<td>0.266</td>
<td>-0.072</td>
<td>0.218</td>
</tr>
<tr>
<td>Constant</td>
<td>10.727</td>
<td>3.315</td>
<td>-</td>
<td>3.661</td>
<td>17.793</td>
</tr>
<tr>
<td>IFSL</td>
<td>-0.007</td>
<td>0.021</td>
<td>0.089</td>
<td>-0.051</td>
<td>0.037</td>
</tr>
<tr>
<td>Constant</td>
<td>8.573</td>
<td>3.871</td>
<td>-</td>
<td>0.323</td>
<td>16.823</td>
</tr>
<tr>
<td>IFG</td>
<td>1.238</td>
<td>4.686</td>
<td>0.068</td>
<td>-8.749</td>
<td>11.226</td>
</tr>
</tbody>
</table>

To highlight the accuracy level of the prediction, we will observe in the three Scatter diagrams, the positive regression line and the cloud of points arrangement in relation to these lines.
4. Discussions

The relevance of these results should be regarded with caution, due to the fact that the study comprises a whole team of athletes, who have different development levels of the strength indices. An argument would be a statistical calculation, realized only on those four subjects who had all the values of muscle strength tests within normal parameters. The results of those athletes, calculated on the same pairs of variables, are the following: FMI - DIMM (0.77%); FMN - DIMM (0.71%); FMI DIMM - PART (0.86%); IFMS - PART (0.51%); IFSS - PART (0.55%); IFSL - PART (0.85%); IFG - PART (0.90%). Within normal values of muscular force, IFG has the best correlation index. The most important limit of the study is precisely the insignificant number of subjects with normally developed muscle strength. According to the studies conducted by Firell & Crain (1996) and Nag & Desai (2003), certain anatomical dimensions (height, scale etc.) would have been useful to our research. Along with other specialists who analyzed the importance of the upper torso in throwing to the gate, specific to handball game (Dinko, Goran, Munir, & Eldin, 2010; Marques, Roland, Jason, & Juan, 2007), this paper presents the values of strength distributed to the top level of the body. At the same time, there is a good intramuscular correlation on the palms, and so, the isometric force of the fingers plays an important role (Junia & Nobuyuki, 2010). This aspect is no longer relevant, in the case of throwing to the gate accuracy, whereas the visual feedback (Ranganathan & Newell, 2008), the voluntary control of the scapular-trapezium muscularity (Holterman et al., 2009) and the fine coordination of the hands (Jacob, Afshin, Klaus, & Pascal, 2011) are the ones that become essential. So, here is a whole kinetic chain, but presented to you only in the upper torso, so, in an incomplete way. In the present research, some issues can be noticed, that are somehow surprising, also supported by Vuleta, Sporiš, Talović, & Jelešković (2010), where the independent variable, in our case the force, does not necessarily have better correlations by having higher values. When referring to DIMM, a better correlation at the unskilful arm can be seen, even if the values and indices are weaker. Also, it is observed that IFSS has a good correlation with the PART independent variable. We know that the index of scapular strength is the only one not enrolled in the normal parameters. It seems that in this case, the scapular muscularity offers a better relaxation and provides better intramuscular control while throwing to the gate, as it can be seen in the DIMM test for the unskilful arm. The correlations are positive, so it is clear that, with elevated values of strength, the capacity of coordination also improves. If we look at the data of the four athletes who are well developed when speaking about strength, it can be observed that the correlation value IFMS-PART and IFSS - PART is also average (0.51% and 0.55%). A significant correlation is between DIMM and PART (0.86%), which means that, the intramuscular control from DIMM greatly influences the results from PART, too. We can conclude that muscle strength at arms and scapular girdle level is not required to be very high, because, in our case, the four athletes have good values at PART (between 10 and 12 points) and at DIMM. This means that muscular strength does not have to be overly developed on certain segments of the body so as not to impair the capacity of coordination.
Acknowledgments

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