Predictive value of selected tests used to assess factors determining sports results of WTF taekwondo athletes

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**Key words:** WTF taekwondo, logistic regression model

**Summary**

**Introduction.** The aim of the study was to estimate predictive value of selected tests used to assess factors determining very good sports results of taekwondo athletes.

**Material and methods.** The study included 109 taekwondo athletes aged 21.71.78 and it involved measurements of structure, conditioning and flexibility as well as technical, coordination and energetic measurements. An iterative procedure was employed to create a model of logistic regression.

**Results.** In most cases variables describing success factors in sport demonstrated low predictive value regarding the possibilities of predicting success among WTF taekwondo athletes. Of all the examined tests evaluating success factors in taekwondo, the tests that assessed conditioning demonstrated the highest predictive value.

**Conclusions.** Putting an emphasis on factors with the highest predictive value in WTF taekwondo will make it possible to train athletes more economically and to attain sports mastery more quickly.
successes (n=10), was formed to verify the quality of the created logistic regression model.

The research included measurements of structure, conditioning and flexibility as well as technical, coordination and energetic measurements.

As for the parameters of body build, the Quetelet index II was estimated.

Conditioning was assessed using the following tests: standing broad jump, 30-second sit-ups, flying 30-m run, 20-m shuttle run ( beep test) [16].

Flexibility was measured with the length of front and side splits [6].

Technical skills were assessed with the time needed to perform 10 repetitions of dollyo chagi, jirugii momtong and 360° dollyo chagi momtong [17].

Coordination abilities were assessed using the following tests: standing broad jump forwards and backwards, movement of a gymnastic baton and turns on an inverted gymnastic bench [6].

Anaerobic muscle capacity of the lower limbs was measured using a 30-s Wingate test [18]. The following parameters were determined: peak power (W·kg), fatigue index (%) and the time of achieving and maintaining peak power (s).

Seventeen explanatory variables were obtained. In this case the dichotomy of ‘success/no success’ constituted the explanatory variable. The analytical procedure included the following aspects:

1. A model was created for all the explanatory variables (17).
2. The equation obtained was diagnosed in terms of the quality of matching the data.
3. Its predictive value was defined (in terms of probability) for the data used to create the model and for the test data (from outside the set).
4. An iterative procedure was employed and all the combinations of explanatory variables were reviewed (here: 2^17, i.e. 131071) to create an equation that included explanatory variables for which the assumed quality criterion (AIC) was the smallest possible.
5. Points 2-3 were repeated for a new set of optimal explanatory variables.

At first, the correspondence of the distribution of particular variables with a normal distribution was analysed. The Shapiro-Wilk test was employed.

The script defining an algorithm was created on the basis of the P. Biecek programme [19], which was activated and performed on the R platform [20].

Results

A full model (Table 1) turned out to be poorly matched to the data. The results of the abdominal muscle strength test were the only variable that influenced the chance of success/failure significantly. Based on the Wald test results the significance of the model was rejected as a whole, whereas the test of the highest reliability showed considerable significance. Its results depend to a large extent on the number of explanatory variables. Also, broad confidence intervals indicate that in most cases the model is not optimal.

The so-called ROC curve is a graphical way of assessing the matching quality of a logistic model. Every point on the curve shows sensitivity and specificity for various cut-off values. To put it simply, the more curved (towards the upper-left corner) the curve is, the better the model. The area below the curve is also calculated here. It assumes the value [0.5;1]. However, the closer the value of the area to one, the better the model. In the case of the full model and the reduced one, the areas below the ROC curve (Figures 1 and 2) totalled 0.84 and 0.81, respectively. It points to a relatively good and similar predictive ability.

The reduction in the number of explanatory variables meant there were two left. However, the variable defining the capacity of the subjects was not observed in the full model. It shows that standard procedures used to determine an opti-

### Table 1. Results of the procedure of identifying an optimal model (full model)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value of estimated parameter</th>
<th>Standard estimation error</th>
<th>Significance level</th>
<th>OR (%)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>-0.196</td>
<td>0.141</td>
<td>0.46</td>
<td>0.82</td>
<td>0.04-1.07</td>
</tr>
<tr>
<td>Standing broad jump</td>
<td>-0.006</td>
<td>0.001</td>
<td>0.16</td>
<td>0.99</td>
<td>0.06-1.02</td>
</tr>
<tr>
<td>30-s sit-ups</td>
<td>0.123</td>
<td>0.079</td>
<td>0.12</td>
<td>1.12</td>
<td>0.84-1.52</td>
</tr>
<tr>
<td>30-m run</td>
<td>-0.699</td>
<td>0.681</td>
<td>0.30</td>
<td>0.49</td>
<td>0.22-1.09</td>
</tr>
<tr>
<td>20-m shuttle run</td>
<td>0.092</td>
<td>0.036</td>
<td>0.01</td>
<td>1.09</td>
<td>1.02-1.16</td>
</tr>
<tr>
<td>Dollyo chagi</td>
<td>0.255</td>
<td>0.416</td>
<td>0.53</td>
<td>1.29</td>
<td>0.08-2.98</td>
</tr>
<tr>
<td>Jirugii momtong</td>
<td>-0.535</td>
<td>0.384</td>
<td>0.17</td>
<td>0.58</td>
<td>0.04-1.25</td>
</tr>
<tr>
<td>360° dollyo chagi momtong</td>
<td>-0.240</td>
<td>0.289</td>
<td>0.40</td>
<td>0.78</td>
<td>0.06-1.38</td>
</tr>
<tr>
<td>Side split</td>
<td>0.016</td>
<td>0.039</td>
<td>0.67</td>
<td>1.01</td>
<td>0.92-1.10</td>
</tr>
<tr>
<td>Front split</td>
<td>0.048</td>
<td>0.042</td>
<td>0.25</td>
<td>1.04</td>
<td>0.07-1.04</td>
</tr>
<tr>
<td>Turns on an inverted gymnastic bench</td>
<td>0.439</td>
<td>0.252</td>
<td>0.08</td>
<td>1.55</td>
<td>0.08-2.62</td>
</tr>
<tr>
<td>Standing broad jump forwards and backwards</td>
<td>0.008</td>
<td>0.019</td>
<td>0.43</td>
<td>1.00</td>
<td>0.09-1.05</td>
</tr>
<tr>
<td>Movement of a gymnastic baton</td>
<td>-0.004</td>
<td>0.016</td>
<td>0.67</td>
<td>0.99</td>
<td>0.03-1.03</td>
</tr>
<tr>
<td>Peak power</td>
<td>0.079</td>
<td>0.298</td>
<td>0.79</td>
<td>1.08</td>
<td>0.04-1.98</td>
</tr>
<tr>
<td>Fatigue index</td>
<td>-0.005</td>
<td>0.070</td>
<td>0.93</td>
<td>0.99</td>
<td>0.07-1.14</td>
</tr>
<tr>
<td>Time of achieving peak power</td>
<td>0.070</td>
<td>0.209</td>
<td>0.43</td>
<td>1.17</td>
<td>0.07-1.81</td>
</tr>
<tr>
<td>Time of maintaining peak power</td>
<td>-0.355</td>
<td>0.221</td>
<td>0.10</td>
<td>0.70</td>
<td>0.05-1.97</td>
</tr>
</tbody>
</table>

Notes: model diagnostics: AIC=140.42; McFadden pseudo $R^2=0.30$; R/Nagelkerke – 0.46; Wald test – 1.54, p<0.09, LR test – 46.23, p<0.001
Table 2. Predictive accuracy (%) for full distribution

<table>
<thead>
<tr>
<th></th>
<th>min (%)</th>
<th>max (%)</th>
<th>mean (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>For the group used to create a model</td>
<td>7</td>
<td>98</td>
<td>46</td>
</tr>
<tr>
<td>For the test group</td>
<td>5</td>
<td>92</td>
<td>52</td>
</tr>
</tbody>
</table>

Area = 0.84

Figure 1. ROC curve for the full model

Area = 0.81

Figure 2. ROC curve for the reduced model

Table 3. The optimal model after the regression

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value of estimated parameter</th>
<th>Standard estimation error</th>
<th>Significance level</th>
<th>OR (%)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-s sit-ups</td>
<td>0.023</td>
<td>0.010</td>
<td>0.02</td>
<td>1.02</td>
<td>1.00-1.04</td>
</tr>
<tr>
<td>20-m shuttle run</td>
<td>0.014</td>
<td>0.003</td>
<td>&lt;0.001</td>
<td>1.01</td>
<td>1.00-1.02</td>
</tr>
</tbody>
</table>

Notes: model diagnostics: AIC=128.17; McFadden pseudo R²=0.28; RNagekerke = 0.31; Wald test = 21.42, p<0.001; LR test = 38.99, p<0.001

Table 4. Predictive accuracy (%) for reduced distribution

<table>
<thead>
<tr>
<th></th>
<th>min (%)</th>
<th>max (%)</th>
<th>mean (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>For the group used to create a model</td>
<td>8</td>
<td>99</td>
<td>48</td>
</tr>
<tr>
<td>For the test group</td>
<td>3</td>
<td>74</td>
<td>48</td>
</tr>
</tbody>
</table>
mal subset of variables are insufficient. The diagnostics of the reduced model shows that it is matched better than the full model. Information loss as well as predictive abilities are only slightly below the level of the full model (Tables 3 and 4, Figure 2).

### Discussion

Various batteries of tests are employed to define and predict chances of success in many sports. Among those tests an important role is played by out-of-laboratory tests because they are simple, economical and not too time-consuming. Most combat sport researchers have focused on assessing either single indices in competitors [7-9,12] or groups of indices within particular motor abilities, i.e. conditioning [5,10,11] or coordination abilities [21-23]. Predictions were also made but most frequently they did not concern sports results. Instead, they focused on abilities which correlated with e.g. key technical elements in a fight. Abidin, Adam [24] attempted to show a correlation between the height of a vertical jump and key technical elements (kicks) and then they tried to predict the height of a vertical jump on the basis of morphological data (anthropometric factors). In turn, Kazemi [25] determined the strength of the correlation between the number of injuries and success in elite taekwondo athletes.

### References


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Received: 12.06.2015
Accepted: 22.10.2015