1. Argument for the topics

The specialty literature provides very few works defining the handball game effort patterns. By watching a handball game, we can easily notice that the most intense actions are developed while accelerating, which requires a great explosive strength. According to Konzag, a handball player performs during a game 190 changes of rhythm, 280 changes of direction and 40 jumps, which correspond to 509 accelerations, namely around 9 explosive actions per minute.

Because we can’t talk about an isolated gesture, but about numerous actions of starting, stopping, direction changing and jumping, separated by short break moments, it isn’t difficult to understand that in handball the consumed energy is mainly provided by the anaerobic, alactacid and lactacid metabolism, which is sustained and recharged by the anaerobic metabolism.

Data concerning the players’ travel on the field are revealed by Cappuccini, who used the device called “Play Controller”. Through it, players were surveyed during the matches, by noticing that they performed 56 sprints on an average, namely one every 67 seconds, on an average. Sprints were not prolonged, the travel average at a maximum speed being of 13 meters, which means that these sprints didn’t last more than 2 seconds. Cappuccini also showed that a player covered about 4300 meters within a game.

To involve the aerobic metabolism into the handball effort sustaining, two indicators can be used: the lactic acid amount and the heart rate.

As for the heart rate during the games, in specialty literature we find an accordance of its values (145 to 180 beats/minute). However, Acsinte, in a research conducted in 2000, showed that these values were different in girls, as compared to the boys, namely:

- boys: 203 b/min by the end of the maximum efforts and 104 b/min by the end of the recovery period;
- girls: 178 b/min by the end of the maximum efforts and 82 b/min by the end of the recovery period.

These data are influenced by the athletes’ age and individual characteristics.

To be able to evaluate the aerobic system intervention, we can relate to the aerobic threshold heart rate value. By analyzing the heart rate value during the game, we notice different values for different positions. Thus, the less stressed is the pivot, for whom the heart rate average expressed in percents, as
compared to the anaerobic threshold, is of 83%, which places it at about 75% out of the VO₂max. The values for the 9-m players are of about 93% and for the wingmen of 92% out of the anaerobic threshold heart rate.

Heart rate is referential to the aerobic system and we can assert that the aerobic metabolism role consists in contributing to the regeneration of those energetic substrates which allow the performing of some quality explosive actions. These are short duration actions, fact emphasized by the reduced amount of lactic acid present in the muscle fiber. In the same research of 2000, Acsinte found the following lactate values:

- boys: 11,5 mmol/l by the end of the effort and 8,92 mmol/l by the end of the recovery period;
- girls: 11,78 mmol/l by the end of the effort and 5,9 mmol/l by the end of the recovery period.

From all we have presented before, it results that the anaerobic effort moments have a short duration, but they are very frequent. This determines a specific training orientation to this effort type. By considering this necessity, we thought to realize a system meant to evaluate the maximum anaerobic power, the way it lowers during the effort and how the body adapts to this effort type.

2. Proposed evaluation methods

To minutely understand this method, we think it would be useful to make some theoretical considerations. Thus, the mechanical power is equal to the mechanical work (labor) performed within a time unit (second). If it lasts more seconds, the measured power is the average one and if the labor is performed once, in an acyclic way and with a maximum effort, the power is maximum instantaneous.

Having in view the specific effort characteristics in handball, we think that measuring the maximum instantaneous anaerobic power (MIAP) and the maximum anaerobic power (MAP), as an average value on 50 seconds, is appropriate to the handball game.

Consequently, in order to measure these powers, we propose the “50-second Test” that consists in performing a 50-second standard effort represented by vertical jumps on both feet from the standing position, effort which aims at checking both the jump height and the number of jumps.

For the MIAP measuring, three successive jumps are performed, by taking into consideration the highest jump. For the MAP measuring, the jumps are measured on the following time intervals: 1 to 5 s; 6 to 10 s; 11 to 15 s; 16 to 20 s; 21 to 30 s and 31 to 50 s (six effort stages).

By knowing the jump height and number within each time interval (we reckon the jump height average) and each subject’s weight, on a nomogram basis (see figure) and through analytical calculations, we determine the MIAP and MAP in any training stage and for each tested subject.
But knowing only the MIAP and MAP values is not enough for a correct interpretation of the anaerobic effort capacity. That is why we conceived the following equations based on the MAP values on different effort stages, which give us further information about the anaerobic effort capacity and the body adapting to this effort type.

1. **INDEX OF THE LOWERING RATE (ILR)** - obtained after each effort stage, through the ratio between the MAP in the respective stage and the MAP in the last effort stage:

   \[ ILR_1 = \frac{MAP_1}{MAP_6}; \quad ILR_2 = \frac{MAP_2}{MAP_6} \text{ etc.} \]

2. **GLOBAL INDEX OF THE LOWERING RATE (GILR)** - obtained through the ratio between the mean of the first five ILR minus 1 and number 5:

   \[ GILR = \frac{\left[ (ILR_1 - 1) + (ILR_2 - 1) + (ILR_3 - 1) + (ILR_4 - 1) + (ILR_5 - 1) \right]}{5} \]

3. **ADAPTATION INDEX (AI)** - obtained through the ratio between the final GILR and the initial GILR:

   \[ AI = \frac{GILR_f}{GILR_i} \]

**MAXIMUM INSTANTANEOUS ANAEROBIC POWER**

**Method of the Interdisciplinary Research Center - UNEFS Bucharest**

Weight (kg), Jump height = h (cm), Extension = gravity center raising (cm)

Weight = 40, 50.. 100, h = 10, 10.2.. 100, Extension (Weight) = Weight x25+15

\[ W = 60, 65.. 90 \]
\[ \text{POWER} (h, W) = 2.21 \times (W \times 9.81) \times \left[ \frac{h}{100} \right]^{1.5} + \frac{100}{\text{Extension}(W)} \times \left[ \frac{h}{100} \right]^{1.5} \]

**NOMOGRAM OF THE MAXIMUM INSTANTANEOUS ANAEROBIC POWER**

*Values specific to physical effort in MEN’S HANDBALL*
3. Interpretation of the evaluation methods

ILR and GILR, through their dynamics reflect a certain resistance to fatigue, therefore a certain anaerobic effort capacity determined by the training process, respectively by the methods of using the training means.

The ILR and MAP lowering indicates the training level improvement in relation to the anaerobic effort capacity, the fatigue onset being slower during the standard effort. At the same time, the GILR mean value lowering indicates a higher training level concretized in a better adaptation to the anaerobic effort.

Through the adaptation index (AI) value lowering, it is expressed the progress ratio of each handball player training level, the progress being greater as the AI is more reduced.

By making a comparison between the dynamics of the effort through the “50-second Test” by the end of a training period and the effort in the beginning of the respective period, we can see if the athletes have adapted to the anaerobic effort. If the adaptation to this effort type has been achieved, the fatigue onset during the test is slower, with lesser diminutions from one effort stage to another.

4. Conclusions

The “50-second Test” using and the interpretation of its results, correlated with the effort characteristics in handball, allow us to select the most correct training means, in relation to their inclusion into different effort zones.

In handball, two indices are used for the effort intensity assessment:
- number of the technical-tactical actions related to the time unit (motor activism);
- average frequency of the heart contractions (FHC).

In most of the specialty works, the FHC is thought to be the index which reflects the most appropriately the influence of different factors upon the athletes’ body functional state.

Matveev (1980) drew up the following scale of the training and competition effort intensity:

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Points</th>
<th>FHC/10 sec</th>
<th>FHC/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>1</td>
<td>18 - 19</td>
<td>108 - 114</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>20 - 21</td>
<td>120 - 126</td>
</tr>
<tr>
<td>Mean</td>
<td>3</td>
<td>22 - 23</td>
<td>132 - 138</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>24 - 25</td>
<td>144 - 150</td>
</tr>
<tr>
<td>Great</td>
<td>5</td>
<td>26 - 27</td>
<td>156 - 162</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>28 - 29</td>
<td>168 - 174</td>
</tr>
<tr>
<td>Maximum</td>
<td>7</td>
<td>30 - 31</td>
<td>180 - 186</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>32 - 33</td>
<td>192 - 198</td>
</tr>
</tbody>
</table>
To determine the effort complex value, we make the product between the effort volume (expressed in minutes) and its intensity (expressed in points). Experimentally, it was proved that the effort intensity increase if it is accompanied by an increase of the number of points per minute.

In handball players’ efforts, particularly with reference to physical training, we found out some lack of consistency in the effort intensity linear dependence, as compared to heart rate. This proportionality is kept only in the case of small, mean and mean-great efforts, namely at a FHC of 110 to 165 beats/minute.

The following table indicates the increases depending on the FHC:

<table>
<thead>
<tr>
<th>FHC</th>
<th>114 to 156 b/min</th>
<th>156 to 180 b/min</th>
<th>180 to 192 b/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>535 - 1285 Kgm/min</td>
<td>1285 - 2250 Kgm/min</td>
<td>2250 - 3050 Kgm/min</td>
</tr>
</tbody>
</table>

Therefore, on the portion between 114 to 156 b/min, the FHC increase by 1b/min determines the power average increase by 18 Kgm/min. On the second portion, between 156 to 180 b/min, the FHC increase by 1 b/min determines the power average increase by 44 Kgm/min and on the third portion, between 180 to 192 b/min, the FHC increase by 1 b/min determines the power average increase by 66 Kgm/min.

In other words, on the second portion the power increase is 2.4 times greater than on the first one, while on the third portion it is 3.6 times greater.

Consequently, we made a correction of the effort points in the Matveev’s table:

<table>
<thead>
<tr>
<th>Intensity zone</th>
<th>FHC/10s</th>
<th>FHC/min</th>
<th>Matveev’s scale</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>18 - 19</td>
<td>108 - 114</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>20 - 21</td>
<td>120 - 126</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Mean</td>
<td>22 - 23</td>
<td>132 - 138</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>24 - 25</td>
<td>144 - 150</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Great</td>
<td>26 - 27</td>
<td>156 - 162</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>28 - 29</td>
<td>168 - 174</td>
<td>6</td>
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<tr>
<td>Maximum</td>
<td>30 - 31</td>
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<tr>
<td></td>
<td>32 - 33</td>
<td>192 - 198</td>
<td>8</td>
<td>30</td>
</tr>
</tbody>
</table>

The effort value assessment can be achieved only if we take into account the used means. Thus, in the case of a technical-tactical training, where the FHC/min average value is of about 150 b/min and where the effort minute is evaluated at 4 points, it is possible to get 180 points if the work lasts 45 minutes. But the same 180 points can be obtained if the work lasts 6 minutes at a FHC of 190 b/min.
To conclude, the evaluation method proposed by us consists in measuring the maximum instantaneous anaerobic power (MIAP) and the maximum anaerobic power (MAP), this method being susceptible to become an efficient tool in the handball players’ training process directing and evaluation.

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