PHASE STRUCTURE AND METHODS OF TRAINING IN SHOOTING WITH REAR CROSS JUMP STEP IN HANDBALL

Ivan Yotov – NSA "V. Levski"

The use of an aggressive style of defence requires specific skills from the contemporary forwards in order to obtain the best position against the opponents’ defence. They should always be prepared for a change of action in line with the game situation on the pitch and should react accordingly. This calls for a continuous improvement of the movements of the lower limbs, the trunk and the upper limbs to guarantee the successful scoring of goals. Shots from a standing position after accelerating with three steps are often used by the constructive players (circle runners and centre). In line with the basic structure of the movement shooting with cross back jumped step can be divided into five phases.

**Method:** Implementation of the study with rear cross jump step was carried out by a highly skilled handball player aged 21, height 193cm and weight 82kg. Two standard digital VCRs provided the registration of movement. The data was processed through the original video computer system. For a comprehensive analysis, three top execution performances with the highest linear velocity of the ball were selected, then the measurements were normalised in the time domain (phase of the overall movement) and averaged. A 14-segment model of the human body was used, defined by digitising the location coordinates of 17 specifically chosen points of the body and one more for the ball. To smooth the digitised data, a digital low-pass filter with partial damping was used with a cut-off frequency equal to the sixth harmonic of the natural movement frequency. To determine the time structure more precisely, source data was reconstructed using modified cubic splines interpolation with a sampling rate set at 100Hz. Subsequently, the kinematic parameters of the movement were calculated from the so-processed output data.

**Phase I – Preparatory:** It involves the player’s initial movement with a step forward until the foot touches the base (duration 0,58 sec).

![Fig.1: Structure of the preparatory stage.](image)

The main aim of the player at this stage is to locate and balance in time and space the particular links of the kinematic chain “handball player – ball” (lower limbs, trunk, upper limbs) in the best way for performing the cross jumped step. The start is from a standing position (fig. 1). The legs are at the width of the pelvis with the right leg slightly forward, almost perpendicular together
with the shoulders in the direction of the shot. The ball is held with both hands close to the chest. The player looks forward. The movement begins by transferring the centre of gravity to the right leg.

*Fig. 2* shows the gradual increase of the linear velocity of the common centre of gravity which, at the time of touching the base, reaches 1,16 m/s. The vertical velocity of the common centre of gravity increases to 0,90 m/s at the first stage of the step and falls to 0,59 m/s at the time of touching the base.

![Figure 2: Dynamics of the increase of velocity of the common centre of gravity](image)

The negative velocity shows the lowering of the common centre of gravity from 1,16 m at the time of touching the base to 0,95 cm midpoint of the step. What is typical of the structure of the internal phase is that the length of the steps is different. The data is presented in *Table 1*.

*Table 1*

<table>
<thead>
<tr>
<th></th>
<th>1&lt;sup&gt;st&lt;/sup&gt; step [см]</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; step [см]</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; step [см]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.83±5.3</td>
<td>0.77±4.6</td>
<td>114.0±5.1</td>
</tr>
</tbody>
</table>

The gradual increase of the linear velocity and the lowering of the common centre of gravity contribute to the stabilization of the kinematic structure at the time of contact with the base when getting ready for the jump. This provides the optimum stability for the player to perform the second phase.

**Phase II – Cross Back Jumped Step**: It starts with a rear push and jump and continues until the leg eponymous to the throwing hand establishes contact with the base (duration 0.48 sec).
The phase starts with a rear push (fig. 3). The right foot is taken off the floor and is moved forward and behind the support leg with a slight flexion in the knee while at the same time the left (support) leg goes through depreciation with duration of 0,12s. The common centre of gravity continues to decrease to 0,9cm, (local minimum) with a following jump, t=0,16s (the angle of the jump with the left leg is between 120° and 125°), and at the time of the vertical the right foot touches the base (the jump is 13cm high and the overall length of the step is 0,77 cm).

The linear velocity of the common centre of gravity increases from 1,29 m/s to 2,94 m/s and at the contact with the base it decreases insignificantly to 2,92 m/s (see Fig. 4). The vertical velocity of the common centre of gravity changes from 0,48 m/s to 9,42 m/s at the time of detachment from the base, and the acceleration increases from 2,82 m/s² to 5,05 m/s² at the first stage of the flying phase and reaches 4,12 m/s² at the time of touching the base.
Phase III – Torsion. The torsion starts at the time of the vertical from a double base after the first stroke. The duration of the third phase is 0.23 sec.

During the forward step the transfer of the ball to the front begins (first stroke). Until the second part of the first stroke the elbow plays the leading part $a_x = 41.3 \text{ m/s}^2$, $a_y = 33.9 \text{ m/s}^2$. Players use a number of variants to bring the ball forward in the preparatory phase. The first stroke is performed simultaneously with the landing, the depreciation and the powerful rear push and the rotation of the heel outwards (outward rotation), so that the forearm, the wrist and the hand bring the ball forward almost at the level of the head. The hand holding the ball is in a position of pronation.

Phase IV – Throwing: The second stroke begins from this dynamic position. (See Fig. 6). The throwing of the ball ends with its detachment from the hand. The duration of performing this is 0.17 sec. Fig. 6 shows the linear velocities of the joint centres of the arm. The figure illustrates how the kinematic chain functions based on the energy transfer from the proximal to the distal end which is a prerequisite for the effective transfer of energy to the ball. The peak values of the velocities are distributed sequentially in time allowing for the whip-like movement of the elbow and wrist joints.

Fig. 6: Structure of torsion and throwing with a back cross step.

Fig. 6: Peak values of the velocities at the surveyed points
Table 2 shows the results from the maximum linear velocities at the same points and the time needed to get to them in relation to the beginning of phase I. In view of the smooth performance of the whole movement, the distribution of the four phases in time is very important.

**Table 2**

<table>
<thead>
<tr>
<th>Points in the kinematic chain</th>
<th>Maximum linear velocity [m/s]</th>
<th>Time [ms]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip joint</td>
<td>3,01±0,11</td>
<td>240±4</td>
</tr>
<tr>
<td>Shoulder joint</td>
<td>5,38±0,17</td>
<td>280±11</td>
</tr>
<tr>
<td>Elbow joint</td>
<td>9,80±0,24</td>
<td>360±8</td>
</tr>
<tr>
<td>Wrist joint</td>
<td>16,10±0,32</td>
<td>400±6</td>
</tr>
<tr>
<td>Hand</td>
<td>24,11±0,31</td>
<td>400±6</td>
</tr>
</tbody>
</table>

Table 3 shows the duration of the separate phases in seconds.

**Table 3:** Time pattern when performing the three steps

<table>
<thead>
<tr>
<th>1st step [sec]</th>
<th>2nd step [sec]</th>
<th>3rd step [sec]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.56±0.05</td>
<td>0.48±0.04</td>
<td>0.40±0.03</td>
</tr>
<tr>
<td>(1:2)</td>
<td>(2:3)</td>
<td>(1:3)</td>
</tr>
<tr>
<td>85.7 %</td>
<td>83.3 %</td>
<td>71.4 %</td>
</tr>
</tbody>
</table>

Fig. 7 presents the values of the acceleration in the transmission of the impulses from shoulder to elbow, from elbow to wrist, from wrist to palm and then to fingers.
When performing the steps, the time pattern is of considerable importance. The duration of the first step is determined by the location of the player with the ball and by his active position. The second step is of shorter duration. It depends on the height and length of the flying phase at the time of the jump. At the time of the third phase, throwing is performed. A maximum effort is exerted at that time. This is why the duration of this movement is very short.

**Phase V – Tracking the ball**: After the ball is detached from the hand (see fig. 8), the movement forward continues while the player tacks the ball with his eyes, arm and body. When the fourth step with the leg eponymous to the throwing hand has been performed, the movement is discontinued.

![Fig. 8. Structure of tracking the ball at the last phase of throwing.](image)

Based on the analysis of shooting from a standing position with a cross back jumped step some of the main kinematic characteristics have been defined. Analysed are the parameters of the phase structure and the internal phase features of performing the throwing. The analysis allows us to reach the following significant conclusions:

- At the preparatory phase optimum stability of the player is observed as a result of the recorded lower location of the common centre of gravity at the time when the left foot touches the base and of the gradual increase of the linear velocity.
- At the second phase when the jump is performed there is a flexion of the knee joint and outward rotation in the hip joint of the leg eponymous to the throwing hand which help regulate the length of the jump.
- The highest values of velocity have been measured at the time of transmission of the impulses from shoulder to elbow, and from elbow to wrist, palm and fingers. This is the result of the synchronization of the transmission of the movement, and, above all, of the two whip-like movements of the elbow and wrist joints.
- At the time of performing the preparatory phase the sole of the bouncing foot should be placed at an interior angle of about 20°.
- The jump is performed at an angle of about 120-125° in the knee joint. This is a good enough reason to design weight lifting exercises focused on this priority zone in the second half of the preparatory phase and the competition period.

**Methods of training**

**First phase**: Elaboration of an initial programme for management of the motor action.

- **Step One**: Acquainting handball players with the technique of shooting from a standing position through: Verbal description; Demonstration – building a visualization of the motor action; Instruction – providing methodological guidance for the implementation of the
technique.

- **Step Two**: Decoding of verbal and visual image of shooting from a standing position; Classification of techniques depending on the available programmes.

- **Step Three**: Preparing a management programme. The latter is implemented as a result of the analysis of the verbal and visual picture of the motor action, and based on existing genetic and acquired programmes.

- **Step Four**: Use of auxiliary exercises, thus a more adequate programme is built for a shorter period. Exercise 1: Cross step running; Exercise 2: Jump running.

- **Step Five**: Manual impact (using direct hand aid).

**Second phase**: Refinement of the motor action management programme.

The transformation of the system (of the handball player) is achieved through the use of an already constructed programme and its improvement through:

1. Incentives (encouraging correct performance).
2. Penalties (adjustment and amendment).

The combination of rational adjustments to the programme with sensory amendments to the practical exercises enhances the process of improving motor action. This approach is implemented through:

   a) **Standard exercise**: This exercise is aimed at achieving implementation of the shooting with minimal deviations in kinematic and dynamic parameters.

   b) **Intermodal exercise**: Here there are significant changes in kinematic and dynamic parameters resulting from the change of position and distance to the target (Fig. 9 and Fig. 10).

![Fig. 9 Shooting beside a passive defence player](image_url)
![Fig. 10 Shooting from the position of the back players](image_url)

**Third phase**: Reaching the state of the system for instant modification of the management programme for shooting, from a standing position depending on game situation.

- **Step One**: Improving polyvariability in performing the exercises with the required intensity.

- **Step Two**: Training by placing in a conditional situation. This approach is related to the implementation of exercises upon a variety of signals. Typical situational signals are the position of the goalkeeper, the defence, the co-players, the referee decisions, etc.

- **Step Three**: Learning through game. Game motor activities have a tactical management aspect, which, from a cybernetic point of view is called reflexive governance. The initial motor skill in the game does not translate into sustainable motor habit but acquires properties of the "higher motor skill."
References:


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Yotov I., Comparative analysis of shots at the door of the Bulgarian national handball team - men in tournaments “Serdika”, Collection of scientific works, book 4, 1985