Effect of takeoff angle change on takeoff velocity and flight distance in swim-start.

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Introduction

The starting technique is one of the important factors for the sprint performance in competitive swimming. In the past, few studies analyzed starting movement in detail while numerous studies compared different starting techniques. During the swim-start, the takeoff angle affects the horizontal velocity at the takeoff and the flight distance. Therefore, the takeoff angle selection is very important for the performance. The purpose of this study was to investigate the effect of the takeoff angle change on the takeoff velocity and the flight distance.

Methods

There were two experiments in this study. In the experiment 1, ten elite competitive swimmers participated after giving informed consent (6 males and 4 females). Each subject performed a usual grab start from the starting block. The starting trials were recorded from a sagittal view at 250 fps by 2 high speed cameras (Photron FAST-CAM). The 2D-DLT method was used for calculating kinematic variables. In the experiment 2, three males’ subjects whose takeoff angles were positive value, were instructed to lowering their takeoff angles in comparison to the experiment 1. The experimental set-up and the methods for analyzing were same as the experiment 1. The takeoff angle was defined as the angle between the velocity vector of the center of gravity and horizontal plane. The body angle was defined as the angle between the horizontal plane and the line that center of gravity was connected with the starting block edge.

Results

Figure 1 shows the relationship between the takeoff angle and the body angle at the takeoff. There was significant correlation in these relationship (r = 0.97, p< 0.01). Figure 2 shows the relationship between the takeoff angle and the mechanical work (J/kg). There was significant correlation in both variables (r = 0.71, p< 0.05). The changes of each kinematic variable are shown in Table 1. In comparison to the usual trials (Experiment 1), the takeoff angle and the body angle at the takeoff decreased, the takeoff velocity increased, the change of the flight distance was small (Table 1). There was no difference of the lower limbs movement in usual trials (Experiment 1) and lower trials (Experiment 2).

Discussion

High correlation between the takeoff angle and the body angle at the takeoff was indicated in these relationships. This result suggested that the takeoff angle was determined by the body angle at the takeoff. The body angle expresses the degree of the rotational movement of the whole body around the starting block edge. The takeoff angle was done by adjusting the degree of the rotational movement in grab start. A remarkable finding was the increase of the takeoff velocity in the lower trials (Experiment 2). Horizontal velocity gains were obtained by not only the kicking to the starting block, but also the rotational movement of the whole body around the starting block edge. It was suggested that increasing the degree of the rotational movement around the starting block edge caused increasing the takeoff velocity in the lower trials. There has been believed that the flight distance would decrease according to lowering the takeoff angle, but there was no change in the flight distance because of the increase in the takeoff velocity. From the correlation between the takeoff angle and the mechanical work (Fig. 2), the selection of the higher takeoff angle was not proper for the effectiveness of the takeoff velocity in swim-start. It was concluded that swimmer should select the lower takeoff angle around 0 degrees.

References


Table 1 Comparisons of the takeoff angle (\(\theta_{\text{takeoff}}\)), the body angle at the takeoff (\(\theta_{\text{bt}}\)), the takeoff velocity (\(V_{\text{takeoff}}\)), and the flight distance in subject K, S, and T.

<table>
<thead>
<tr>
<th>Subject</th>
<th>(\Delta\theta) (deg)</th>
<th>(\Delta V) (m/s)</th>
<th>(\Delta d) (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub.K</td>
<td>-2.9</td>
<td>4.9</td>
<td>3.40</td>
</tr>
<tr>
<td>Sub.S</td>
<td>-1.0</td>
<td>2.8</td>
<td>3.34</td>
</tr>
<tr>
<td>Sub.T</td>
<td>-7.5</td>
<td>0.8</td>
<td>3.21</td>
</tr>
</tbody>
</table>

\(\Delta\theta = \exp 2 - \exp 1\)
}\(\Delta V = \exp 2 - \exp 1\)
\(\Delta d = \exp 2 - \exp 1\)