Characteristics of Static and Dynamic Balance Abilities in Competitive Swimmers

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Abstract Competitive swimmers may have inferior balance because antigravity strength exertion, which is used to stand, is not often necessary in the water. This study concerns the ability to stand with the manipulating and supporting legs and their laterality by examining 16 male competitive swimmers (age: 19.4±1.0 years, career: 13.7±2.1 years) and 16 male general university students (age: 20.6±1.2 years). Static balance and dynamic balance were evaluated by the center sway of foot pressure and stability on an unstable stool, respectively. The total path length, mean path length, maximal amplitude rectangle, root mean square area, and outline area for the former and the fluctuation index for the latter were selected as evaluation parameters. The results of a two-way ANOVA (group × leg) showed no significant difference in both the group and leg factors for static balance parameters. In contrast, the dynamic balance parameter showed a significant difference in both. Stability on an unstable stool was higher in the swimmer group than in the general student group and in the manipulating leg than in the supporting leg in both groups. In conclusion, dynamic balance while standing is superior in competitive swimmers, unlike static balance assessed by the center sway of foot pressure. In addition, dynamic balance in the manipulating leg is superior to that in the supporting leg for both groups.

Keywords: static balance, dynamic balance, competitive swimmers


1. Introduction

Balance ability is one of the most important physical fitness factors. It is mainly used while standing and has a close relationship with factors, such as the visual system [1], the vestibular system [2], somatic sensation [3], and leg strength [4]. In addition, balance ability is classified into static and dynamic balance. The former is the ability to stabilize the center of gravity (COP) within a supporting base during static standing, and the latter is one to move it in a new supporting base when being interfered with stability or to maintain stable posture within a supporting base by body movement [5].

It is very important to have superior balance for high performances because many competitive sports are performed in a standing position. Antigravity muscles are involved in maintaining the standing posture [6]. However, the exertion is not always necessary when swimming due to effects of buoyancy [7]. Hence it is hypothesized that competitive swimmers who trained in water for many years have inferior antigravity muscles compared to other competitors [8]. Thus, they are inferior in static and dynamic balance abilities related to antigravity strength.

On the other hand, Noguchi et al. [9] reported that laterality is found in the dynamic balance ability to stand on one leg in general male university students. Laterality means the side of the body people prefer to use in daily activities. Until now, laterality has mostly been studied in upper limbs [10,11,12]. However, in the case of lower limbs, Demura et al. [14] reported that people prefer to use a specific leg when hopping on one leg or kicking a ball. Swimming repeats symmetrical movement, and both legs are used equally. Therefore, laterality may not be seen in the balance ability to stand on one leg in competitive swimmers, who have practiced in water for many years.

This study examines the differences in static and dynamic balance abilities and their laterality between competitive swimmers and general university students.

2. Methods
2.1. Participants

Participants included 16 male competitive swimmers (age: 19.4±1.0 years, height: 172.0±5.7cm, weight: 65.4±4.8kg) with swimming careers longer than ten years (career: 13.7±2.1 years) and a history of participation at the national level, and 16 healthy male general university students (age: 20.6±1.2 years, height: 173.3±5.5cm, weight: 68.6±8.9kg). Nagasawa et al. [13] classified the subjects legs as manipulating leg (used to kick) and supporting leg (used to support the body when kicking a ball) using one item (Which is the leg used to kick a ball?) of the dominant leg survey by Demura et al. [14]. This study employs the same classification. The purpose and procedure of this study were explained to all participants and informed consent was obtained. The present experimental protocol was approved by the Ethics Committee on Human Experimentation of Faculty of Human Science, Kanazawa University (Ref. No. 2012-06).

2.2. Static Balance

Static balance has been assessed by measuring the center sway of body gravity while standing [15,16,17]. A Gravicorder G5500 (Anima, Japan) was used to measure foot pressure in this study. This device calculates the center of foot pressure path, mean path length (mean length of the center of the foot pressure path), maximal amplitude rectangle (area surrounding the maximal amplitude rectangle for each axis), root mean square area (area of the circle creating the actual effective radius value), and outline area (area surrounding the center sway of body gravity while standing [15,16,17]. A gravitational moment of gravity used to kick a ball) using one item (Which is the leg used to kick a ball?) of the dominant leg survey by Demura et al. [14]. This study employs the same classification. The purpose and procedure of this study were explained to all participants and informed consent was obtained. The present experimental protocol was approved by the Ethics Committee on Human Experimentation of Faculty of Human Science, Kanazawa University (Ref. No. 2012-06).

2.3. Dynamic Balance

Table 1. Differences in static balance parameters among groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Manipulating leg (M)</th>
<th>Supporting leg (Sup)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Total path length (cm)</td>
<td>G1</td>
<td>105.3</td>
</tr>
<tr>
<td></td>
<td>G2</td>
<td>108.0</td>
</tr>
<tr>
<td>Mean path length (cm/s)</td>
<td>G1</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>G2</td>
<td>3.7</td>
</tr>
<tr>
<td>Maximal amplitude rectangle (cm²)</td>
<td>G1</td>
<td>11.4</td>
</tr>
<tr>
<td></td>
<td>G2</td>
<td>14.0</td>
</tr>
<tr>
<td>Root mean square area (cm²)</td>
<td>G1</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>G2</td>
<td>3.8</td>
</tr>
<tr>
<td>Outline area (cm²)</td>
<td>G1</td>
<td>11.3</td>
</tr>
<tr>
<td></td>
<td>G2</td>
<td>9.4</td>
</tr>
</tbody>
</table>

Table 2 shows the statistics and results of the two-way ANOVA (group × leg) of static balance parameters. No significant difference was found for the parameters.

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2.4. Statistical Analysis

The mean differences of static and dynamic balance parameters were tested by a two-way ANOVA (group × leg). When significant interactions or mean effect was found, a multiple comparison test was conducted using Tukey’s Honestly Significant Difference (HSD) method for multiple comparisons. The significance level in this study was set at p < 0.05.

3. Results

Table 1 shows the statistics and results of the two-way ANOVA (group × leg) of static balance parameters. No significant difference was found for the parameters.

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4. Discussion

Static balance has been assessed by the center sway of body gravity in a standing posture [15]. Tanaka et al. [15], Kitabayashi et al. [16], and Matsuda et al. [17] assessed static balance by the center of foot pressure when participants stood on a force plate for a specific amount of time. In this study, a similar method was used to evaluate the participants’ static balance. As a result, no significant difference was found in all static balance parameters between the swimmers and general student groups and between the manipulating and supporting legs. Competitive swimmers train in the water with buoyancy for a long time. Hence, it is hypothesized that they have inferior static balance, important for the standing posture, due to the little use of antigravity muscles as compared to the general students. However, this hypothesis was rejected and no significant difference was found between both groups.

Hahn et al. [21] reported that the one-leg stand time with closed eyes showed no significant difference among soccer players, handball players, basketball players, badminton players, tennis players, gymnasts, and swimmers. In addition, Matsuda et al. [17] examined static balance among soccer players, basketball players, swimmers, and non-athletes, and reported no significant difference between swimmers and non-athletes. University competitive swimmers in this study had swimming careers longer than ten years and competition history at the national level, and the non-athletes were general university students of similar ages. It is considered that competitive swimmers could perform the one-leg stand easily for 30 s, similar to the general students, if the standing posture was not disturbed during the measurement.

Matsuda et al. [17] reported that laterality was not found in static balance for the one-leg stand in soccer players, basketball players, swimmers, and non-athletes. No significant difference was found in each static balance parameter between the swimmers and general students in this study. Many activities of daily life, such as walking, ascending, and descending stairs, and standing up, necessitate the use of both legs. Swimming is also an exercise that repeats symmetrical movement, and both legs are used equally; therefore, laterality was not found.

The one-leg stand on an unstable moving stool such as the DYJOC board forced subjects to maintain a stable posture under a peculiar condition and demanded the ability to retain the stable posture by using the body’s core and legs. The present results show that the swimmer group is superior in the dynamic balance of each leg than the general student group. Davlin [22] also reported that swimmers are superior to general students in dynamic balance. Seifert et al. [23] reported that expert swimmers are superior in their limb coordination. According to Shimojyo et al. [24], swimmers should attach great importance to the following somatosensory factors: resistance of water, joint angle, physical position, and exercise efficiency. To reduce swimming times, it is important to reduce water resistance, and somatosensory function is demanded in the water. Because the present competitive swimmers have experience at the national level, they are considered to have superior somatosensory function.

In addition, Liao and Lin [25] reported that a strong relationship was found between the center of mass displacement and the angular displacement of the ankles. Demura and Matsuura [26] and Demura et al. [27] reported that ankle flexibility is important for kicking in swimming. In short, it is inferred that the present competitive swimmers have greater ankle flexibility than the general students. Also, even in the case of a largely inclined wobble board, they could easily maintain a stable posture by coordinating their ankle joints.

Noguchi et al. [9] examined the laterality of dynamic balance in general university male students and reported that the manipulating leg was superior to the supporting leg. The result for the general students in this study is similar to that in Noguchi et al. [9]. In addition, it was found that the dynamic balance of the manipulating leg is superior in competitive swimmers to that of the supporting leg. Both legs are used equally in daily life. However, in the case of special movement, such as kicking a ball, one leg is preferably used and the other leg contributes to maintaining a stable posture and allowing for easier control of a ball. In short, the role of each leg is different. When kicking a ball, it was shown that the manipulating and supporting legs present similar results for general students and competitive swimmers who repeatedly practice symmetric movements. From these results, the manipulating leg with high operability may have superior ability to maintain a stable posture on the continuously changing stool stability to the supporting leg.

5. Conclusion

No significant difference was found in the static balance assessed by the center of foot pressure between competitive swimmers and general students and between manipulating and supporting legs in both groups. However, dynamic balance is superior in competitive swimmers than in general students and in the manipulating leg to the supporting leg.

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Conflict of Interest Statement

None.

References