Functional Role of Upper Limbs and Hip in During Control Balance Hand Stand Performance in Male Gymnasts

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ABSTRACT: Balance is a part of physical fitness related to sport performance and plays a major role in almost all sport skills. This part of physical fitness plays a determining role in sport skills such as wrestling, gymnastics, and skiing to mention a few. The purpose of this study was to determine the role torque of upper limbs and hip joint in control balance during handstand performance in the male gymnasts. Ten gymnasts with an average age (18/21±1/10 years), height (165/69±4/21 cm) and weight (60/38±3/89 kg) participated in this study. Eight spherical markers were placed on their bodies on defined landmarks. Using motion analysis system with three cameras and a force plate, recorded handstand performed for five seconds. Kinematics data includes position, velocity and acceleration of angular limbs and joints of the body in the WINANALYZE software and Information kinetic (force) that was calculated by the BIOWARE software. The measurements Anthropometric was determined included limb mass, limb center of mass position and length of each limb. Two-dimensional model Defining of the five-part to the inverse dynamics method. The of wrist joint, elbow, shoulder and hip torque were calculated in MATLAB software. ANOVA statistical method used for data analysis. The most angular changes were observed in wrist, whereas the P<0.05 shoulder, hip, knee and elbow joints were observed, consequently. The most changes in torque were observed followed by elbow, shoulder, and thigh, respectively.

Keywords: balance, torque, inverse dynamic, angular joint.

INTRODUCTION

Maintaining balance and stability for performing daily activity as well as sport skills is necessary. Despite such an important task in life, man had not been able to examine all the details of maintaining balance and many questions including how balance is established remains unanswered.

The majority of the researches in exercise science have attempted to examine the precise details of factors involved in maintaining balance. For instance, some researches have examined factors associated with balance control in age group, different senders and during the affliction to some disease involving the neuromuscular system (Horak , Nasher, 1986; Vuillerme , et al 2001; Daneshmandi , et al 2006). Three major physiological preperioceptive mechanisms, ocular and vestibular systems work together to inform the performer about the condition of his/her body and interact to maintain the balance. The information provided this way is synchronized in the central nerve system and put into action to prepare a required response (Daneshmandi, et al 2006).
The majorities of the researches conducted in this regard have focused on standing on two feet position (Horak, Nashner, 1986; Winter DA 1990; Runge F , et al 1999). Considering the muscle excitation and various limb movements in two foot stance, ankle and thigh joint and walking are known as strategies to maintain balance in lower extremities (Horak 1986). Ankle strategy is the first swing control strategy in standing position. This one is called into action to keep the center of mass within the base of support when the forces aimed at disturbing the balance are small (Horak, Nashner, 1986). Thigh joint is the second strategy. This strategy is applied to keep the center of mass within the base of support when the forces threatening the balance are larger and quicker (Horak, Nashner 1986). However, when the forces disturbing the balance are so large that ankle and thigh strategies fail to keep the center of mass within the base of support, stepping strategy is called into action to maintain the center of mass within the base of support (Horak, Nashner, 1986). Considering such conditions, the contribution of the lower extremity in controlling balance is obvious, whereas such condition during the execution of balance on two hands is not examined. A review of literature in this regard revealed that two distinct researches were conducted to examine this subject. Kerwin , Trewartha (2001) examined the role of torque in wrist, elbow and shoulder joint during the execution of balance stance on both hands and concluded that wrist joint plays a very significant role in controlling the balance (Kerwin, Trewartha, 2001). The limitation of this study was the exclusion of elbow joint contribution to maintaining balance during standing on both hands (Horak FB , Nashner, 1986). In another research, Zarei (2008) studied the role of balance control strategy during the parallel standing skill execution and reported that elbow joint was the second strategy for maintaining balance. The limitation of this study was the two dimensionality of the protocol in addition to lack of inclusion of kinetic parameter in the study of balance strategy examination despite the fact that mathematical equations (Zarei, 2008).

In summary, based on the review of research literature, it can be concluded that the research in the upper extremity part is devoted to two specific subjects: (a) the elbow joint exclusion factor contribution to maintaining balance and (b) the elbow joint exclusive contribution to maintaining balance. Considering this approach, it seemed necessary to conduct study in which comprehensive examination of control strategies in upper extremity is assessed.

**METHODOLOGY**

This was a quasi experimental research conducted in laboratory. The statistical population included elite gymnast athletes from whom 10 male subjects were randomly selected.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Weight(kg)</th>
<th>Height(cm)</th>
<th>Age(yr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of playing gymnastics</td>
<td>60/38±3/89</td>
<td>165/69±4/21</td>
<td>18/21±1/ 10</td>
</tr>
</tbody>
</table>

Before the start of testing procedures, subjects signed human consent form after they were informed about the procedures. Eight markers were installed on anatomical locations such as upper extremity, head and lower extremity to collect the data. The motion analyzer system was equipped with three cameras and one force plate. The speed of recording was set to 120 hz in order to record the motions with the three cameras which were set to 30 degree angle to each other (Asseman, Gahery, 2005). The force plate used in this research was four axes working at 120 hz frequency to record where the subjects was performed. The markers on the right side of anatomical locations of subjects were attached to the wrist, elbow, acromion process, head (temporal bone), thigh (major trochanter), external edge of knee, ankle (external part) and head of fifth phalangus. Following a brief warm up activity and attachment of the markers, the subjects executed a two-hand balance on head on the force plate till they reached to a complete stable balance, then...
the ground reaction and cameras started to record the position of the markers for 5 seconds (Kerwin, Trewartha, 2001).

For the purpose of measuring alterations in the joints angular change, determining the deviations between the connecting lines of each marker placed on the limbs, the angle of that limb with each of the axis or other limb was measured. In this study, the angle between two limbs was defined as the angular joint of that limb.

For the purpose of reducing noise in data, WINANALYZE filter available in this software was used to smooth in the curves and purify the data in the camera and BIOWARE software was used for the same purpose to clarify the data on the force plate.

By defining a two dimensional model in sagital plate including five limbs connected by four joints of wrist, elbow, shoulder and hip, the torque for these joints were calculated by inverse dynamic technique through the Newton-Ouler method. The limbs in this model included hand, elbow, arm, torso and lower extremity. Torso includes head, chest, and abdomen (Kerwin, Trewartha, 2001).

In inverse dynamic method assumption is based on the fact that every limb is a body and is connected to the adjacent limb by a hinge joint. The mass of every limb is located within the center of that limb. It is assumed that torque inertia and center of mass during the motion remain constant and torques and forces are applied in both head of every limb (Nigg, Herzog, 1995; Karik, 2005; Farahmand, Bashiri, 2006).

By using the coordinates of markers, the length of elbow, arm, torso, and feet were determined and the mass and location of the center of mass of every limb was calculated by anthropometric table (Asseman, Gahery, 2005). The inverse dynamic program was written by length, mass, and distance of center of mass to the joint in elbow, arm, and torso; MATLAB and force was written in Excel software in a 13 column by 600 row matrix. The existing matrix in row includes temporal inputs 0.008333 for 5 seconds. The remaining rows include position, speed, and angular acceleration in wrist, elbow, shoulder and thigh joints (Zarei, 2008).

With known inputs of every program in inverse dynamic in MATLAB software for every subject, the torque for wrist, elbow, shoulder and hip joints of all subjects at any motion for 5 seconds is calculated. Statistical methods such as ANOVA were used at the alpha level set to 0.05.

**FINDINGS**

Wrist joint showed the largest change in balance on both hands, while the least change was present in elbow joint. The percent of change in each of these joints were 31.34(wrist), 24.60(shoulder), 20.35 (hip), 12.54 (knee) and 11.61 (elbow).

<table>
<thead>
<tr>
<th>ANOVA</th>
<th>Sum of Squares</th>
<th>Degree of Freedom</th>
<th>Mean Squares</th>
<th>F-Value</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>150/64</td>
<td>4</td>
<td>41/45</td>
<td>10/01</td>
<td>0/00*</td>
</tr>
<tr>
<td></td>
<td>72/34</td>
<td>9</td>
<td>9/7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>222/98</td>
<td>13</td>
<td></td>
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</tbody>
</table>

* p value set to 0.05.

Wrist joint followed by elbow, shoulder, and hip, respectively. These results indicate that the wrist joint plays the most significant role in maintaining the center of mass within the base of support.

Table 2 compares joint angular changes. The result of analysis indicated that there was no significant difference in joints angular change. In addition, the highest amount of joint change were wrist, shoulder, hip, knee and elbow, respectively.

<table>
<thead>
<tr>
<th>ANOVA</th>
<th>Sum of Squares</th>
<th>Degree of Freedom</th>
<th>Mean Squares</th>
<th>F-Value</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>169/25</td>
<td>3</td>
<td>43/74</td>
<td>11/24</td>
<td>0/00*</td>
</tr>
<tr>
<td></td>
<td>59/63</td>
<td>9</td>
<td>9/72</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>228/88</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3 compares joint torque changes of wrist, elbow, shoulder, and hip in subjects in 5 seconds of balance on both hands. The result of analysis indicated that the highest changes occurred in wrist joint followed by elbow, shoulder, and hip, respectively.
* p value set to 0.05.

DISCUSSION AND CONCLUSION

The purpose of this study was to determine the role torque of upper limbs and hip joint in control balance during handstand performance in the male gymnasts. Following the examination of angular changes in wrist, elbow, shoulder, hip, and knee, it was concluded that the most angular changes during the two-hand standing occurred in wrist followed by shoulder, thigh, knee and elbow, respectively.

In this regard, just the study conducted by Zarei (2007) reported the angular changes in wrist, shoulder, hip, knee, and elbow in execution of parallel balance. These findings are similar to the findings of the present research. Probably the reason for observing such similarity can be attributed to the similar procedure used in testing procedures and markers used. Therefore, it can be concluded that angular changes occurring during the parallel balance is similar to what occurs in balance stand on both hands.

However, no research was found to compare the results of angular changes in women subjects. In research conducted to examine the angular changes in standing on both feet, it was concluded that the most angular changes occurred in thigh joint (Runge, et al 1999; Erinl, 2006). Therefore, the results of the present study did not support these results.

This disagreement in external in examining the angular changes in standing on both feet may be due to the difference in standing on both feet comparing to standing on both hands and probably due to the types of positioning of major joints in these two actions.

In the present research, it was observed that four joints, that is, wrist, elbow, shoulder, and hip all have contributed to the maintaining the center of mass within the base of support, but wrist joint shows the highest change in torque and thus it has the major role in the execution of balance on both hands.

According to the results of studies reported earlier, the joints closet to the base of support are the ones that make the major contribution to the maintenance of balance and farer joints are involved in the maximum balance needed to keep the center of mass within the base of support (Kerwin, Trewartha, 2001). The findings of the present research is in agreement with these assumptions since wrist joint is the closest to the base of support in executing two-hand balance stand and has the highest variation in torque. In addition, the results of this study is in agreement with the results of Kerwin (2001) who purposed that the wrist joint had the highest variations in torque and is involved as the main strategy in maintaining the balance in executing two-hand balance stand (Kerwin, Trewartha, 2001). In the research conducted by Kerwin, the elbow role was not included, but this was not the case in the present research.

Also, the findings of the present research is in agreement with the findings of Zarei (2008) who reported that gymnasts’ wrist joint had the most variation in torque during the balance control in standing on both hands on parallel apparatus. Zarei (2008) claimed that torque changes for executing parallel are wrist, elbow, shoulder and thigh, respectively (Zarei 2008). The strength of the present research compared to Zarei (2008) is that in the former research the use of force plate for capturing the ground reaction force.

In the researchers conducted on examining the lower extremity during standing on both feet, it was concluded that the ankle joint had the most torque and plays the main role in keeping the center of mass within the base of support (Runge F, et al 1999; Erinl, 2006). Thus, the finding of this research in upper extremity is identical to findings reported in regard to the lower extremity. Runge (1999) demonstrated in a research that assessing the torque or determining it can be the base for determining the strategy in motions (Runge, 1999). Considering this claim, the strategy used for controlling the balance on both hands is wrist, elbow, shoulder and thigh.

The first strategy in such motion is the wrist action that is somehow similar to what was observed in ankle action during the standing position, that is, acting as an important factor in controlling the center of mass within the base of support. The second strategy is the elbow joint that was not taken into account in Kerwin's research (2001). The third strategy was the shoulder strategy and finally the hip was the fourth strategy examined in this research. The shoulder and thigh joints strategies are similar to the thigh strategy applied during the standing position on both feet.
According to the results of this study, teacher and coaches of gymnastic are suggested to design and implement training programs that emphasizes on wrist action. Since most of the angular and torque changes during the execution of balance action during and balance control involves both hands. In addition, further researches are suggested to examine the subject applying three dimensional approaches including both genders at various age groups.

**General conclusion**

Considering the results of this study, a similarity of pattern in regard to the change in joint torque of subjects in four joints including the wrist, elbow, hip and shoulder in regard to maintaining to balance during the execution of balance on both hands was observed.

**REFERENCE**


