The Comparison of Postural Balance Level between Advanced Sport Climbers and Sedentary Adults

Dicle Aras¹, Koichi Kitano², Alan M. Phipps², Micah R. Enyart¹, Fırat Akça¹, David M. Koceja², Alan W. Ewert³

¹Ankara University Faculty of Sport Sciences, Department of Coaching Education,
²Indiana University Bloomington School of Public Health, Department of Kinesiology,
³Indiana University Bloomington School of Public Health, Professor Emeritus,

ABSTRACT

Besides being an important factor in preventing musculoskeletal injuries in daily life, the sport of rock climbing affects balance as well. Hence, the purpose of the study was to compare the postural balance level between experienced sport climbers and sedentary adults. A total of 10 advanced sport climbers and 10 sedentary adults participated in the study. All subjects performed three balance tasks on a force plate platform with the eyes open, eyes closed, and during a visual conflict condition. All testing was performed with hands on hips and while barefoot. Subjects were instructed to stand quietly on the force plate for 90-second trials. The ranges, and SDs (standard deviation) of sway in the medio-lateral (ML) and anterior-posterior (AP) axes, and the sway path values [on the ML and AP axes and the general sway (mm)] were recorded. Although climbers had superior scores in all of the balance values, only significant differences were found in the Range-ML with the eyes open condition, and in Range-AP and SD-AP with the eyes closed. Intrigroup analyses showed that both groups had statistically higher scores in Range-AP, SD-AP, Sway path, and Sway path-AP values with the eyes closed condition, and only climbers in Range-ML, and only sedentary group in Sway path-ML again with the eyes closed condition. In accordance with the results it can be concluded that advanced level sport climbers produces significant advantages in the postural balance level. Therefore, sport climbing could be evaluated as a type of physical activity to enhance the balance level.

KEY WORDS: postural balance, range, sedentary life, sport climbing, sway path

INTRODUCTION

Being one of the skill-related components of physical fitness, balance has a substantial role in the quality of life of all individuals [1, 2, 3, 4, 5]. Many kinds of daily physical activities require a sufficient level of balance. A decrease in the level of balance can cause musculoskeletal injuries and functional losses in all age groups [6, 7], and this is especially
true as we age [8]. For instance, falls due to loss of balance is one of the major public health concerns for individuals older than 65 years, and falls can result in morbidity or mortality [9]. Postural balance is affected by sensory inputs, muscular strength, neuromuscular control, and joint movement [10]. Since the level of postural balance is mostly related to physical activity [11], it is necessary to exercise regularly to keep the balance ability at a high level. Hence, several studies have investigated the effect of different types of exercise and sports on postural balance [12, 13, 10, 11, 14, 15, 16, 17]. For example, Schmid et al. (2010) reported a four percent enhancement in static balance in an elderly sample after a 12-week Hatha yoga program [11]. Similarly, a positive effect of a 4-week Yoga program was also observed by Ulger and Yagli (2010) [15]. Researchers also reported that both beginners and intermediate participants demonstrated an increase in their sensory and stability indices after a 7-day skiing camp [16]. A study which compared the effects of doing multiple sports to doing only one sport did not find any significant difference on dynamic balance scores in school athletes [13]. A longitudinal study investigated static balance after a year of different exercise training performed 3 times per week for 90 minutes in young athletes. Researchers found that the training groups had significantly better balance score than their non-trained peers [14]. These results, taken together, indicate that the main factor for gaining an adequate level of balance depends on being active more than on the specific type of exercise performed. Huang and Yamamoto (2013) concluded that the frequency of training is also a substantial factor, and balance training increases the balance level only when it is done at least 2 or 3 days per week [18]. According to their study one day of balance training has no effect on balance ability in young adults.

Defined as a physical activity in which the arms are used when the legs do not have the capacity to move the climber over a rock face [19], rock climbing has become a very popular activity in recent years in both competitive and recreational terms [20, 21]. Sport climbing is the most well-known discipline of rock climbing, and can be described in which fixed anchors are placed at set intervals on the climbing wall [22]. This type of exercise involves not only the psychological and cognitive factors such as motivation, anxiety, pain tolerance, concentration, tactical and technical skills, reading the route, making quick decisions, but also the physiological factors like strength, endurance, power, flexibility, body composition, and balance. As balance is identified as an important factor in sport climbing [23, 17] it is thought that sport climbing training can produce a positive effect on balance ability.

Therefore, in the present study, we aimed to measure the postural balance levels of advanced sport climbers, and compare their values with sedentary individuals in order to have information whether it could be suggested that sport climbing training could be used to enhance the postural balance.

METHODS

Participants and study design

Evaluating the balance is crucial to enhance the quality of life of all individuals. Another substantial point is to increase the number of the sport branches or the type of physical activities which is influential on balance. In order to understand how sport climbing effective on postural balance level, advanced sport climbers and sedentary people performed three different postural balance tests in the motor control laboratory for the current study. Executing the balance tasks with the eyes open, eyes closed, and visual conflict conditions provided practical information about the balance level of both of the groups.
Ten advanced sport climbers and ten sedentary adults voluntarily participated in this study. The climber group (5 males and 5 females, age 21.10 ± 2.33 years, height 173.59 ± 10.85 cm, weight 66.35 ± 13.31 kg) consisted of climbers who were at the advanced climbing level according to the UIAA metric scale [24], and the control group (6 males and 4 females, age 23.10 ± 2.33 years, height 179.27 ± 8.66 cm, weight 75.02 ± 13.48 kg) was composed of volunteers who had not participated in any regular physical activity for at least six months, and who did not participate in any exercise programs during the study period.

Participants were invited to the laboratory on two separate occasions. In the first meeting they were informed about the study design of the research and they were asked to fill out the informed consent forms. The second meeting took place in the same motor learning laboratory for participation in the postural balance tests. The research was approved by the Indiana University Bloomington, International Research Board (protocol number: 1412985837).

**Measurements**

Balance tests were performed in three different conditions with the eyes open (EO), eyes closed (EC), and visual conflict (VC). To provide the VC, special eye prism glasses (Bernell Corporation, Model E/RYPA+) were used (Mishawaka, IN). Participants performed three trials for each of the conditions. Each trial lasted for 90 seconds and participants were given 15 seconds resting time between trials and three minutes between conditions, to prevent any fatigue from occurring. To evaluate the balance score the average of three trials was calculated for each condition. The ranges and standard deviation (SD) of the postural sway signal in the medio-lateral (ML) and anterior-posterior (AP) axes, the total sway path value in the ML and AP axes and the overall sway path value (all measurements in mm of sway) were the parameters used to measure the postural balance level in the study.

All the trials were performed on a Kistler Portable Force Plate Type 9286B balance platform Kistler Instruments, Amherst, NY). The subjects practiced one trial of the three different balance condition prior to data collection. The subjects were told to take off their shoes and socks before testing and stand straight during each test with their hands on their hips, and their feet shoulder width apart. All the measurements took place between 2 and 4 pm and the group of participants and conditions of balance test were determined randomly. Sample rate for the balance measurements was set a 2 kHz.

**Statistical analysis**

SPSS 20 (SPSS Inc., Chicago, IL, USA) was used for all statistical data analyses. First, the distribution of data was tested using the Shapiro-Wilk test to determine if the test to be used for average comparison is parametric or not. An Independent-Sample $t$-Test was used for comparisons between groups, and an ANOVA Test was used for comparisons among visual conditions. An alpha value of 0.05 was the criterion used for all of the statistical analyses.

**STATISTICAL RESULTS**

There was no significant difference in the mean age, body height, and body weight values of the two groups. The results of ranges, and SDs on the ML and AP axes values (mm) and average comparisons are shown in Table 1, and in Table 2 the sway path values on the ML and AP axes and the general sway path value (mm) for both the sedentary and the climber groups.
Table 1

The ranges, and SDs on the ML and AP axes values (mm) and their mean differences obtained from different conditions.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Group</th>
<th>Eyes open</th>
<th>Eyes closed</th>
<th>Visual conflict</th>
<th>p_ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range-ML</td>
<td>CG</td>
<td>40.83 ± 6.37</td>
<td>51.88 ± 17.59</td>
<td>43.15 ± 7.95</td>
<td>p= 0.007*</td>
</tr>
<tr>
<td></td>
<td>SG</td>
<td>49.36 ± 10.31</td>
<td>56.01 ± 12.79</td>
<td>49.99 ± 11.98</td>
<td>p= 0.150</td>
</tr>
<tr>
<td>p_ value</td>
<td>CG</td>
<td>p= 0.042*</td>
<td>p= 0.557</td>
<td>p= 0.199</td>
<td></td>
</tr>
<tr>
<td>Range-AP</td>
<td>CG</td>
<td>36.83 ± 6.75</td>
<td>44.51 ± 4.09</td>
<td>39.93 ± 5.22</td>
<td>p= 0.018*</td>
</tr>
<tr>
<td></td>
<td>SG</td>
<td>38.26 ± 6.46</td>
<td>53.42 ± 10.16</td>
<td>44.76 ± 8.67</td>
<td>p= 0.000*</td>
</tr>
<tr>
<td>p_ value</td>
<td>CG</td>
<td>p= 0.634</td>
<td>p= 0.025*</td>
<td>p= 0.153</td>
<td></td>
</tr>
<tr>
<td>SD-ML</td>
<td>CG</td>
<td>6.81 ±1.22</td>
<td>7.89 ± 1.86</td>
<td>6.78 ± 0.94</td>
<td>p= 0.202</td>
</tr>
<tr>
<td></td>
<td>SG</td>
<td>8.21 ± 1.95</td>
<td>8.60 ± 2.01</td>
<td>8.18 ± 2.82</td>
<td>p= 0.407</td>
</tr>
<tr>
<td>p_ value</td>
<td>CG</td>
<td>p= 0.073</td>
<td>p= 0.410</td>
<td>p= 0.226</td>
<td></td>
</tr>
<tr>
<td>SD-AP</td>
<td>CG</td>
<td>5.74 ± 1.44</td>
<td>7.21 ± 1.86</td>
<td>6.37 ± 0.84</td>
<td>p= 0.002*</td>
</tr>
<tr>
<td></td>
<td>SG</td>
<td>6.11 ± 1.21</td>
<td>8.67 ± 1.80</td>
<td>7.08 ± 1.39</td>
<td>p= 0.001*</td>
</tr>
<tr>
<td>p_ value</td>
<td>CG</td>
<td>p= 0.450</td>
<td>p= 0.048*</td>
<td>p= 0.183</td>
<td></td>
</tr>
</tbody>
</table>

CG: Climber group; SG: Sedentary group; ML: Medio-lateral; AP: Anterior-posterior.

In accordance with the analyses between groups, climbers had significantly lower scores in Range-ML with the eyes open condition (40.83 mm vs 49.36 mm), and in Range-AP and in SD-AP with the eyes closed condition (7.21 mm vs 8.67 mm). All other variables showed no significant differences between the climbers and the control group, as shown in Table 1.

Intragroup analyses revealed that the climbers had significantly higher score in Range-ML and Range-AP values with the eyes closed condition than eyes open (p< 0.01 and p< 0.05 respectively). In SD-AP value climbers showed statistically differences between eyes closed and eyes open conditions (p< 0.01), eyes open and visual conflict (p< 0.05), and eyes closed and visual conflict (p< 0.05) conditions. There was found a significantly higher score in Range-AP value with the eyes closed condition than with the eyes open and the visual conflict conditions (p< 0.01), and between the visual conflict and the eyes open conditions (p< 0.05) for sedentary adults. Another differences obtained for sedentary adults were in the SD-AP value. The eyes closed condition was higher than eyes open and visual conflict conditions (p< 0.01), and the visual conflict condition score was higher than eyes open condition (p< 0.05).
Table 2

The sway path values on the ML and AP axes and the general sway path value (mm) and their mean differences obtained from different conditions.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Group</th>
<th>Eyes open</th>
<th>Eyes closed</th>
<th>Visual conflict</th>
<th>p_ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sway path</td>
<td>CG</td>
<td>2566.27 ± 587.74</td>
<td>3005.64 ± 412.56</td>
<td>2647.37 ± 389.56</td>
<td>p = 0.025*</td>
</tr>
<tr>
<td></td>
<td>SG</td>
<td>2705.23 ± 553.15</td>
<td>3244.78 ± 744.84</td>
<td>2823.57 ± 512.96</td>
<td>p = 0.001*</td>
</tr>
<tr>
<td>p_ value</td>
<td></td>
<td>p = 0.705</td>
<td>p = 0.389</td>
<td>p = 0.389</td>
<td></td>
</tr>
<tr>
<td>Sway path-ML</td>
<td>CG</td>
<td>2020.35 ± 396.87</td>
<td>2208.72 ± 268.59</td>
<td>2003.32 ± 378.22</td>
<td>p = 0.082</td>
</tr>
<tr>
<td></td>
<td>SG</td>
<td>2037.75 ± 410.78</td>
<td>2355.78 ± 456.92</td>
<td>2098.27 ± 363.50</td>
<td>p = 0.000*</td>
</tr>
<tr>
<td>p_ value</td>
<td></td>
<td>p = 0.924</td>
<td>p = 0.394</td>
<td>p = 0.574</td>
<td></td>
</tr>
<tr>
<td>Sway path-AP</td>
<td>CG</td>
<td>1435.74 ± 278.11</td>
<td>1784.34 ± 365.79</td>
<td>1472.94 ± 136.31</td>
<td>p = 0.003*</td>
</tr>
<tr>
<td></td>
<td>SG</td>
<td>1502.58 ± 311.82</td>
<td>1878.22 ± 533.79</td>
<td>1590.54 ± 309.73</td>
<td>p = 0.002*</td>
</tr>
<tr>
<td>p_ value</td>
<td></td>
<td>p = 0.619</td>
<td>p = 0.653</td>
<td>p = 0.293</td>
<td></td>
</tr>
</tbody>
</table>

CG: Climber group; SG: Sedentary group; ML: Medio-lateral; AP: Anterior-posterior.

There was no significant change between groups in Sway path, Sway path ML, or Sway path AP values.

According to the Table 2, climbers showed higher score in Sway path value with the eyes closed condition than with the eyes open and visual conflict conditions (p < 0.05 and p < 0.01 respectively). In Sway path-AP climbers had a higher score with the eyes closed condition than with the eyes open and visual conflict (p < 0.01 and p < 0.05 respectively). In the Table two it was observed that sedentary group showed significantly higher score with the eyes closed condition than with the eyes open and visual conflict conditions in Sway path (p < 0.01), Sway path-ML (p < 0.01), and Sway path-AP values (p < 0.01 and p < 0.05 respectively).
The aim of the present study was to compare the postural balance level between advanced level sport climbers and sedentary adults. We hypothesized that sport climbing is a type of physical activity in which balance is one of the substantial factors that would be effective on postural balance level.

Although the only statistically significant differences between groups were Range-ML (p= 0.042) value with the eyes open condition, Range-AP (p= 0.025), and SD-AP (p=0.048) values with the eyes closed condition, climbers had better scores than their sedentary peers in all the parameters (Range-AP, SD-ML, SD-AP, Sway path, Sway path-ML, Sway path-AP with the eyes open condition; Range-ML, SD-ML, Sway path, Sway path-ML, Sway path-AP with the eyes closed condition; and Range-ML, Range-AP, SD-ML, SD-AP, Sway path, Sway path-ML, Sway path-AP with the visual conflict condition). Since climbing requires the body to keep in balance in different body positions climbers need to have the motor control at a sufficient level during climbing [25], these positive changes observed in climber group are consistent with the literature in the present study. Another research about sport climbing and balance was done by Ignjatovic et al. (2016) [23]. Eleven 16-year-old female climbers who participated Youth World Cup in 2015 performed the Flamingo balance test, one leg standing along on a balance bench (OLSB), and cross standing on a balance bench (CSBB). According to their results the boulder climbers had better balance scores than the lead and speed climbers. They also found relationships between lead climbing and flamingo test, and between CSBB and speed climbing. However, as mentioned in the introduction section training frequency and scope are other substantial factors which enhance balance [18]. Balas and Bunc (2007) investigated the effects of a ten-week climbing training in 7-9 years old pupils. Climbing...
trainings were done for 45 min per session and twice a week. After the training period, 135 school children did not show any difference in the balance score as measured with the Flamingo balance test [12].

The reason for the lack of the significant differences could be dependent on a number of factors. First, similar body composition values might have a key role on it. It is relatively accepted that having a higher level of body mass index requires more motion while maintaining the postural balance [26], obesity decreases the postural balance level [27, 1, 28, 29]. Nevertheless both of the groups had similar body height and body weight values.

Another reason for the small number of significant differences may be the method used in the study. Rock climbing requires sport-specific hand and foot techniques. Climbers generally tend to use only the big toe, and very few times the heel to gain the balance on a hold instead of using the whole foot. However, postural balance level was measured with the whole foot in the present study. This could be second reason of having slightly differences between groups. It is also possible that few differences were observed between groups since both the climbers and the control group were relatively young, with little decrements in balance performance. Perhaps examining older climbers would be beneficial, to answer the question as to whether climbing activities helps to delay the loss of postural control in an aged sample.

Another result derived from the study was the evaluation of the alteration of the postural balance level regarding three different visual conditions applied with the eyes open, eyes closed, and visual conflict conditions. Both groups showed similar changes. Climbers had more balance deterioration with the eyes closed condition than with the eyes open in Range-ML, Range-AP, SD-AP, Sway path, and Sway path-AP values. They had also higher scores with the eyes closed condition than the visual conflict in SD-AP, Sway path, and Sway path-AP values. In SD-AP parameter climbers had also higher score with the eyes open condition than visual conflict. Sedentary adults showed more deterioration with the eyes closed condition than eyes open and visual conflict conditions in Range-AP (p<0.01), SD-AP (p<0.01), Sway path (p<0.01), Sway path-ML (p<0.01), and Sway path-AP (p<0.01, p<0.05 respectively) values. Sedentary group had also higher deterioration with the visual conflict condition than eyes open condition in Range-AP and SD-AP values (p<0.05). The only value in which no difference was found is the SD-ML for both of the groups. In accordance with the results it could be inferred that both of the groups, independently from the physical activity level, show more deterioration with the eyes closed condition and then visual conflict condition, and lastly with the eyes open condition. The study showed that people have more likely to lose the balance when the visual information is eliminated or disturbed, due to the loss of peripheral proprioception [2]. The efficiency of the visual information on the balance level was also found by Maitre et al. (2014). They reported that all sensory manipulations cause more deterioration in postural balance in older women.

CONCLUSION

In conclusion; it was observed that sport climbing improves the postural balance score. Hence, sport climbing could be evaluated as a type of physical activity to enhance the balance level. However, in order to observe the alterations in balance score according to the climbing grade, comparing the balance level among beginner, intermediate, advanced, elite, and higher elite sport climbers could be more efficient. Thus researchers can observe the effects of climbing grades on balance score. Additionally, researchers can use different
methods to measure the balance of climbers for the future studies. Standing with the big toe on a force platform and try to protect the postural balance for a shorter time could be a more effective identifier than the method used in the present study.

REFERENCES


