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Comparison of static and dynamic balance parameters and some performance characteristics in rock climbers of different levels

Tolga AKSIT[1], Gamze CIRIK [2]

[1] *Department of Coaching Education, Faculty of Sport Sciences, Ege University, Izmir, Turkey.*
[2] *Institute of Health Sciences, Sport and Health Sciences, Ege University, Izmir, Turkey.*
Address correspondence to T. Aksit, e-mail: tolga.aksit@ege.edu.tr

Abstract

The aim of the present study was to compare anthropometric characteristics, dynamic balance and physical performances of climbers at recreational and intermediate levels. Climbers were seperated in two groups according to climbing difficulty levels. A total of 24 male rock climbers; 16 at beginner level (mean ± sd; 26.2 ± 4.2 years, climbing grade; 6a/6a+) and 8 intermediate level (mean ± sd; 30.8 ± 4.9 years, climbing grade; 7c/7c+) participated voluntariliy in the study Measurements were taken from both groups for anthropometric (body height, weight, body fat ratio, skinfolds, humerus breadth, arm span), intermittent finger hang (IFH), bent-arm hang and hand grip strength. Static (open/closed eyes) and dynamic balance was measured with isokinetic balance test on a force platform. Differences between groups were calculated using an independent samples t-test and also Mann-Whitney U test was used for nonparametric values. As a result, advance group has significantly greater values for limits of stability, humerus breadth, ape index and IFH ($p<0.05$). No significant difference was found between groups for the other balance parameters, anthropometric characteristics and climbing performance factors. In consequence, static balance parameters of rock climbers were found to be similar to those of other elite athletes in the literature. On the other hand, dynamic balance could be considered to be a more important parameter than static balance for climbers by the nature of the sport.

Keywords: Balance, rock climbing, strength, performance.

INTRODUCTION

Balance is defined as the ability to keep the "body's center of gravity". In this respect, this coordinative ability is a process which includes the coordinated activities of sensory, motor and many biomechanical components (6,26).

The view of neuromuscular control can be achieved through postural control measures. In the related literature, postural control and balance are grouped into static and dynamic categories (11,18,33). The central nervous system (CNS) needs to keep the body position in static and dynamic conditions for keeping balance and the production of suitable forces. CNS maintains this position stability by coordinating the information coming from sensory receptors (2).

A good postural performance is of vital importance to achieve success and avoid injuries in many sports (17). In this context, the literature includes studies analyzing postural performance in dividing athletes by their levels in several branches (18,24,28,29,31). In a study compiled by Şimşek & Ertan (26), postural balance and performance relations were shown in such sports as rifle shooting, basketball and gymnastics and the importance of balance was highlighted. Aalto et al. (1) carried out a study with rifle shooters and sedanteries and found smaller body sway movements in hooters. Likewise, a relation was found between postural balance and successful free throws in basketball players as well (22).

Climbing is a sport based on pulling up body weight against gravity (7,25). Therefore, body composition is an important performance parameter in climbers. Although there are studies on anthropometric characteristics of athletes in the literature, it can be seen that there are controversial results (8,10,31). Moreover, rock climbing is a sport that requires good postural control for keeping the balance under challenging conditions. Studies carried out on performance factors in rock climbing include those focusing on anthropometry and muscular resistance (7,9); however, no study has been found concerning balance in the literature. For this reason, the aim of the present study is to analyze and compare anthropometric characteristics, dynamic balance and physical performances of climbers of different levels.

With this study, anthropometric characteristics, dynamic balance and physical performances of intermediate (IC) and advance climbers (AC) will be examined. The results to be obtained will provide infonrmation about the factors affecting climbers' performances and these factors will be taken into consideration while designing training plans.

MATERIAL & METHOD

Experimental Approach to the Problem

The participating athletes were divided into two groups according to their climbing levels and sporting backgrounds. All participants made 3 visits for all the tests applied. On the first day, anthropometric measurements and body fat ratios were taken. Right after the measurements, the participants were taken to the 10-minute adaptation session on the isokinetic balance device for the evaluation of their balance parameters. Body mass, height and sum of skinfold (7side) measurements were taken of intermediate and advance level climbers to determine anthropometric characteristics. On the 2nd day, static and dynamic balance parameters were assessed on the isokinetic balance device. The day after, in order to determine climbing performance characteristics, intermittent and bent arm test and hand grip (dominant arm) were performed.

Subjects

A total of 24 male rock climbers (16 IC and 8 AC) at different levels participated in the present study voluntarily. Participants' age, height, weight, climbing experience, physical and performance characteristics are presented in Table 1. This study was approved by the Medical Research Ethics Committee of Medical University Hospital (Ege University-protocol no: 16-12/9). Informed written consent was obtained from all climbers. The climbing history questionnaire was used to obtain information about the frequency of climbing and the self-reported climbing ability of the participants.

Study Protocol

Anthropometry, Body Composition, Body mass (kg) and height (cm) were obtained using a standard scale and a stadiometer. Body mass and total body fat (%) were calculated using the Tanita BC-418MA Segmental Body Composition Analyzer (Tanita Corp., Tokyo, Japan). Skinfolds (mm) were measured at 7 sites: triceps, subscapular, biceps, suprailiac, abdomen, thigh and calf, using a skinfold calliper (Holtain Ltd, Crymych, UK). The perimeters of the biceps, fore arm and arm span were measured (cm) and also biepicondylar humerus (elbow) was measured. Ape index is calculated with the ratio of climbers' arm span divided by their height. The circumference values were obtained using a single evaluator and a flexible tape measure with a precision of 0.1 cm. The Body Mass Index (BMI) was calculated as the body mass divided by the stature squared.

The adjustable handgrip dynamometer (Takei, range 0-100 kg, Tokyo, Japan) was used to evaluate hand-grip strength (HG). In standing position, the participants grasped the dynamometer with the elbow fully extended beside the body. Participants performed 3 attempts, with a 3-min rest between attempts. The highest value of the three trials was chosen. Relative strength was calculated by dividing the obtained values by the individual's body weight.

Bent-arm Hang (BAH)

The participants were told to hold 'jug holds' on fingerboard as long as possible in full block position until failure. The climber's chin was hold above the bottom of the fingerboard and was not allowed to touch the fingerboard during the test. The test was stopped when the climber's eyes dropped below the bottom of the fingerboard (6).

Intermittent Finger Hang (IFH)

Climbing involves intense intermittent isometric contraction by forearm muscles. A climbing specific hang to rest ratio for 8:4 seconds was chosen to perform the test. The climbers hanged by straight-arm position on the 2.5cm depth on fingerboard. Hanging on the edge was performed with four fingers with open grip position.

Static and Dynamic Posturography

Evaluations of standing static and dynamic balance parameters were carried out with an isokinetic balance device containing a force platform (20 Hz sampling rate and a sensitivity of 0.1°-ProKin, Tecnobody; Italy). During these measurements, the

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athletes were positioned so as to center both feet (barefoot) on the origin by referring to the lines on x and y axes on the platform. They were asked to stand and hold their hands free. Static stability assessment was carried out with the athletes eyes open and (OE) and closed (CE) for 30 seconds. Instant positions of the center of pressure (COP) on the platform were calculated with the following variables:

- Average anterior-posterior velocity (Velocity AP),
- Average medial-lateral velocity (Velocity ML),
- Surface area (mm2),
- Length of COP path,
- OE/CE length ratio.

In the limit of stability (LOS) evaluation, maximal limits that the athletes can reach on static platform were calculated. The value was assigned in % here. In the multiaxial proprioceptive evaluation, the value was assigned as average track errors (ATE) and test duration was 60 seconds. Total track followed, ellipse area, and low ATE parameters reflect a good posture. The role of visual stimuli was assessed with Romberg's quotient by comparing the data obtained from CE and OE.

Statistical Analysis

Data analysis was carried out by using the SPSS 20.0 program (SPSS, Inc., Chicago, IL). The results are presented as means. Shapiro-Wilk test was used to check for normality of the distribution of each data variable. Differences between groups were calculated using an independent samples t-test. Nonparametric values were shown as '¥', and the Mann-Whitney U test was used to compare the values. Significance was established at $p \leq 0.05$.

RESULTS

Descriptive data of participants are shown on table1. When compared with AC, a difference was observed in IC in terms of athlete background and climbing levels; however, the two groups are similar in descriptive data such as height and weight.

The anthropometric values and static/dynamic balance parameters are shown in table 2. The results presented that AC had significantly higher on IFH time than IC ($p<0.05$). On the other hand, no difference was found in climbing-characteristic parameters between the groups. In terms of anthropometric characteristics, no difference was observed between the groups in measurements except for humerus breadth. Figure 2-3 shows displacement of COP on x-y axes in OE and CE conditions for AC and IC. In the examination of the balance tests, LOS performances of AC were significantly better than the other group (figure 3).

Table 1. The anthropometric and climbing characteristics of subjects (Mean ± SD).

Variables	Intermediate (n=16)	Advance (n=8)
Age (years)	26.2 ± 4.2	30.8 ± 4.9
Height (cm)	176.6 ± 5.4	178.7 ± 6.5
Body mass (kg)	68.4 ± 8.2	69.4 ± 7.8
BFR (%)	8.8 ± 3.5	9.7 ± 2.2
FFM (kg)	62.2 ± 6.9	62.6 ± 5.9
BMI ($kg{\cdot}m^{-2}$)	21.8 ± 1.9	21.7 ± 2.1
Climbing grade	6a/6a+	7c/7c+
Climbing experience (year)	5.0 ± 3.2	10.1 ± 3.7

BFR: body fat ratio; FFM: fat free mas; BMI: body mass index

DISCUSSION

The aim of the present study was to compare balance parameters, anthropometric characteristics and climbing specific strength parameters of climbers of different levels. Our hypothesis was that balance and some strength parameters of the advance group would give higher values. The results of the study supported the hypothesis that advance climbers had significantly greater values than the other group for LOS, humerus breadth, ape index and IFH. The advance climbers in our study are in the 7c/7c+ range according to the international mountaineering and climbing federation (UIAA) climbing grade chart.

The finding of this study is that anthropometric characteristic and climbing-specific performance determinants of climbers differed according to the level of climbers. According to anthropometric measurements, humerus breadth was higher in the advance group. When compared to the contol groups in the previous studies carried out on sportive climbing, it was shown that the climbers had lower body fat ratios, height and weight (15,25,31). In this study, especially AC has shown similar anthropometric characteristics that were mentioned above with previous findings. In studies concerning sportive climbing, the ratio between arm span and height (ape index) is addressed as one of the determiners of climbing performance (32). Higher ape index would provide advantage for climbers to reach a next handhold. Similarly in our study, we found a significant difference for ape index in AC than IC.

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Table 2. Comparison of the anthropometric and static/dynamic balance data intermediate and advance climbers (Mean ± SD).

	Intermediate (n =16)	Advance (n =8)	Difference	p
Climbing Characteristics				
¥Intermittent finger hang (s)	103.0 ± 39.9	225.1 ± 75.5	122.1	**0.001**
Bent-arm hang (s)	39.6 ± 12.7	49.7 ± 12.3	10.1	0.078
Hand grip(relative)(kg)	0.75 ± 0.8	0.77 ± 0.5	0.02	0.495
Anthropometric characteristics				
Sum of 7 skinfold (mm)	74.1 ± 21.8	60.0 ± 18.1	14.1	0.130
Humerus Breadth (cm)	6.6 ± 0.4	7.1 ± 0.2	0.4	**0.015**
Biceps girth relaxed (cm)	29.7 ± 2.8	29.8 ± 2.6	0.1	0.938
¥Fore arm girth (cm)	27.3 ± 1.8	27.7 ± 1.2	0.4	0.853
Arm span (cm)	178.7 ± 7.0	185.0 ± 8.6	6.3	0.069
Ape index	1.01 ± 0.01	1.03 ± 0.02	0.02	**0.013**
Static balance parameter				
¥Velocity AP [OE] (mm/s)	6.2 ± 1.1	7.3 ± 1.3	1.1	0.062
¥Velocity AP [CE] (mm/s)	9.6 ± 2.0	10.8 ± 3.1	1.2	0.578
¥Velocity ML [OE] (mm/s)	5.6 ± 1.7	5.1 ± 1.6	0.5	0.492
¥Velocity ML [CE] (mm/s)	7.4 ± 2.8	7.3 ± 3.0	0.1	0.877
Length of COP path [OE] (mm)	289.6 ± 59.9	298.2 ± 53.7	8.6	0.735
Length of COP path [CE] (mm)	411.4 ± 95.6	446.0 ± 133.6	34.5	0.472
¥Surface area [OE] (mm^2)	149.5 ± 63.2	182.7 ± 99.4	20.8	0.540
¥Surface area [CE] (mm^2)	260.8 ± 185.1	236.5 ± 96.9	24.3	0.736
¥ OE/CE area ratio	168.3 ± 91.3	166.5 ± 107.5	1.8	0.976
Dynamic balance parameter				
¥ATE (%)	41.0 ± 16.2	35.2 ± 13,2	5.8	0.358
¥Limit of stability (%)	86.2 ± 12.1	96.2 ± 3.8	10	**0.025**

Bold p-values are those significant at a 0.05 level (two-tailed); ¥means values are compared as nonparametrics; AP: anterior-posterior; ML: medial-lateral; OE: open eyes; CE: closed eyes; ATE: average track error.

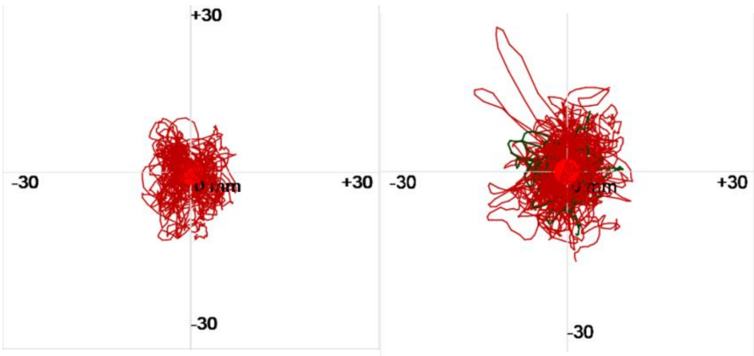

Figure 1. Superimposed displacement of center of pressure (COP) on x-y axes in open eyes condition of advance and intermediate climbers.

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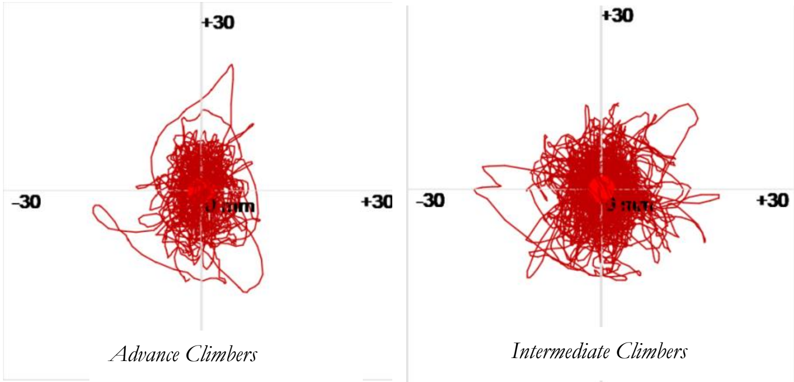

Figure 2. Superimposed displacement of center of pressure (COP) on x-y axes in closed eyes condition of advance and intermediate climbers.

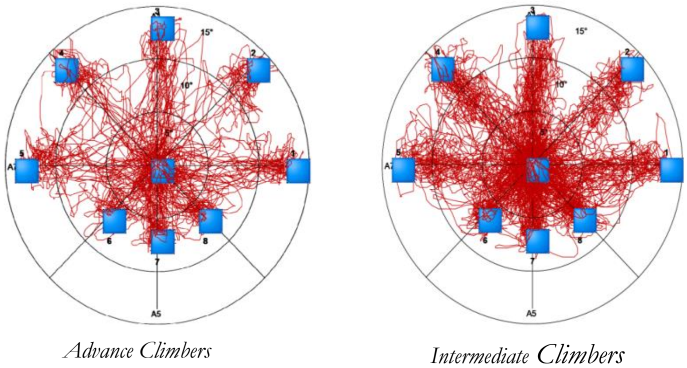

Figure 3. Superimposed displacement of limits of stability on 9 section in advance and intermediate climbers.

In the present study, measurements for climbing characteristics (IFH, BAH and HG) gave higher scores for AC, but among these values, the differences in AC values were significant in IFH times only.

The present study suggesting static balance parameters both AC and IC showed similar results. No significant differences were found in the COP surface between groups in the AP, ML postures. The literature includes studies comparing static balance parameters of athletes and sedentary individuals in several sports. In their study, Paillard et al. (20) found that judoists had statistically better static balance levels in comparison with sedentary individuals. They used the displacement of velocity, length of COP path and surface area as balance parameters. In another study conducted by Göktepe et al. (8), as a result of the OE static balance test performed on handball, volleyball and football players. The total distance taken was found as 304.76 mm while it was 298.2 mm for AC and 289.6 mm for IC in our study. These findings are the indicators that the climbers in both groups have good postural balance. Hence, it is stated that abdominal, back extensors and calf muscle group are responsible for the maintenance of postural balance and that the force of anterior leg muscle group is of great importance (26,13,14). It is reported that the muscles that are important in keeping postural balance are used actively during climbing and therefore force gains of these muscles are higher (3,23,25). Therefore, rock climbers may be expected to have good balance. Balance parameters in the present study are parallel with those mentioned in the related literature.

In the present study, no significant difference was found between IC and AC in terms of static balance parameters. The literature includes studies comparing balance abilities of athletes of different levels (12). Static balance parameters have been examined in elite and non-elite throwers of different levels and all examinations have shown that advance athletes have better balance (5,16). Likewise, it has been observed that unipedal and bipedal static balances of footballers at national levels have better parameters than footballers at local levels (21). However, contrary to expectations, athletes' being at elite level do not affect postural balance in some sports. In previous studies, no significant difference was found between the balance performance of

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athletes from different level in gymnastics, surf and judo branches (4,20,28). Chapman et al. (4) connected this condition in surfers to unstable surface and environmental conditions. The results of our study support this finding. Although athletes are not on unstable surfaces while climbing, their stepping positions vary by the structure of the rock surface. Therefore, the climber has to position his/her feet according to different surfaces each time, which may highlight the fact that dynamic balance is of greater importance than static balance in climbers. As for dynamic balance, no significant difference was found between the ATE values of the two groups while LOS was observed to be better in AC compared with IC. LOS test performed on the force platform determines the percentages of reaching 9 regions as shown in Figure 3 and thus it is an application with a high level of difficulty.

In one study carried out with gymnasts, Vuillerme et al. (27) stated that the athletes' levels did not have any effect on accomplishing simple tasks like both feet static balance control. In another study, it is stated that the ability to keep balance would be distinctive depending on the level of the task to be accomplished and it was proposed that IC needed to put more effort to regulate the increase in the sways on the platform in maintaining the balance (30). In the LOS test in which the difficulty of postural tasks increased, a difference appeared between the two groups in terms of dynamic balance. Since climbing includes moves that require extending to left and right and that the steps are not flat, it could be more appropriate to test the LOS parameter included in the postural control evaluations. This explains why AC showed a greater performance in LOS.

This study was the first to our knowledge to compare the ability of balance in climbers of different levels. As a result, significant differences were found in the ape index and humerus breadth in the anthropometric structures of AC and IC. As for climbing performance, on the other hand, better results were obtained in the advance group in IFH test only. Similarly, there were significant differences between groups in the LOS percentages of balance parameters. AC's percentages of reaching the specified parameters were better in comparison with IC; however, no significant difference was found between the groups in terms of static balance parameters. In this respect, it could be suggested that dynamic balance tests would be more appropriate for use in climbers. Future studies should focus on the relationship between balance parameters and climbing-specific performance determinants to emphasize the importance of balance in rock climbers.

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