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# BALANCE IN YOUNG GYMNASTS: AGE-GROUP DIFFERENCES

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**Abstract**. *The aim of this study was to investigate the differences in balance test scores and success on the balance beam of young gymnasts competing at the international level of competition. Forty-eight young female gymnasts divided into two age groups participated in the study (Group 1: n=22, age 9.0 ± 1.1 years, height 136.0 ± 7.6 cm, weight 30.8 ± 4.3 kg; Group 2: n=26, age 12.1 ± 0.6 years, height 146.0 ± 7.0 cm, weight 36.9 ± 6.6 kg). For the assessment of static balance, the participants had to perform three stance variations (double leg, single leg and tandem) on stiff surfaces and the three specific static-balance tests consisted of gymnastics elements on the balance beam (scale, handstand and side handstand). For the assessment of dynamic balance, the participants had performed multidirectional maximal single-leg reaches from a unilateral base of support (Y - balance test) and three specific dynamic-balance tests which consisted of a connection of two gymnastic elements (the 360° turn, jump with a rotation of 180° and the cartwheel). In the static balance tests there is a significant difference only in the one-leg stance (.021) and the specific static balance test (.000). In the dynamic balance tests, there was a significant difference in performing two cartwheels between the two groups (p=.043). These results suggest that the older gymnasts had better results in demanding tests such as the one-leg stance, handstand, and cartwheel on the balance beam. To achieve top results in Women's Artistic Gymnastics it is necessary to achieve good results on the balance beam, and monitor balance ability.*

**Key words**: *artistic gymnastics, balance beam, static balance, dynamic balance.*

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## INTRODUCTION

Gymnastic training stimulates the development of balance and allows almost perfect stability, even under extreme conditions (Atilgan, Akin, Alpkaya & Pinar, 2012). There are numerous factors that affect balance, and the most important are genetic determinism, the state of the vestibular apparatus, age, area of support, the amount of body balance, the number of motor habits, their fitness, strength, coordination, flexibility, emotional state, muscle fatigue (Cetin, Bayramoglu, Aytar, Surenkok & Yemisc, 2008; Kayapinar, 2011). As a basic sport, artistic gymnastics affects the development of motor skills: strength, coordination, flexibility, and balance (Albuquerque & Farinatti, 2007; Carrick, Oggero, Pagnacco, Brock & Arikan, 2007). In terms of coordination, gymnastic elements are grouped in the most complex movements. The testing and periodical monitoring of young athletes are also important for defining the training program, tailored to the demands of sport and age. This ensures a harmonious and healthy development of fundamental motor skills in accordance with the physical development of athletes (Ricotti, 2011). The specifics of athletes in sports disciplines are the result of selection, but also of the specific effects of the action that creates the discipline (Čuk et al., 2007).

Balance, along with other motor skills, plays an important role in the successful execution of sports skills, as well as in the prediction of sport injury (Sabin, Ebersole, Martindale, Price & Broglio, 2010). A potential link between balance and injury has resulted in the increased interest in the development of instruments (tests, assignments, exercises) for the purpose of creating balance improvement programs and reducing the risk of drug violations (Sabin et al., 2010; Zech et al., 2010). Balance training is also used as a part of a rehabilitation program after injury of the ankle and knee joint (Hrysomallis, 2011). Balance is an important factor for success in many sports, particularly in gymnastics, because even minimal distortion affects the final score. During the development of motor skills, coaches need to be very systematic and conscious of the fact that motor efficiency is one of the most important issues. Only physically well prepared gymnasts will be able to perform gymnastic elements and compose technically correct exercises without injuries. Training programs should be composed to give enough time to practice and to develop motor skills (Marinsek & Velickovic, 2010).

The balance beam, as one of the most demanding disciplines in women's all-around competition, requires the ability to balance at a high level, because it has extremely reduced surface support of 10 cm, height of 1.25 m, and a length of 5 m. Balance is important for the performance of complex acrobatic elements (Panjan & Sarabon, 2010) as well as dance elements that are required in the performance of gymnastic composition. In defining the elements of exercise on the balance beam, it is often stated that most of the content on this apparatus is taken from the floor, but differences in the construction of apparatus should be borne in mind, which lead to differences in the technique. Gymnasts perform gymnastic elements on the beam with a very reduced area of support. There are elements that require balancing on hands and feet, so on this ability depends on the efficiency of the element execution (Hars, Holvoet, Gillet, Barbier & Lepoutr, 2005).

Compensatory movements of the body are essential for maintaining balance in order to bring the body’s center of gravity above the supporting surface. If these movements are more pronounced and accompanied by additional hand, legs or torso movements, in order to prevent the fall of the apparatus during competitions, they are sanctioned by the judges.

In most studies, the balance of gymnasts was compared with the balance in the group of non-athletes (Vuillerme et al., 2001; Aydin, Yildiz, Yildiz, Atesalo & Kalyon, 2002;

Carrick et al., 2007; Assemani, Caron & Crémieux, 2008) or with the balance of other athletes (Davlin, 2004; Bressel, Yonker, Kras & Heat, 2007). The aim of this study was to investigate differences in balance test scores and success on the balance beam of young gymnasts competing at the international level.

## THE METHOD

### The sample of participants

Forty-eight young female gymnasts, divided into two age groups, participated in the study (Group 1: n=22, age 9.0 ± 1.1 years, height 136.0 ± 7.6 cm, weight 30.8 ± 4.3 kg; Group 2: n=26, age 12.1 ± 0.6 years, height 146.0 ± 7.0 cm, weight 36.9 ± 6.6 kg). Before the testing begun, the aim and procedures of the study were explained to the participants. Finally, all the participants reported that they had not had any ligamentous laxity, articular or muscle trauma or injury during the past three months. The project was approved by the Institutional Review Board of the University of Niš and the Gymnastics Federation of Serbia and written consent had been obtained from all the participants and coaches prior to participation in this project. All of the experiments were conducted according to the latest version of the Declaration of Helsinki (World Medical Association, 2002). The data collection was completed at International memorial competition "Laza Krstić and Marica Dželatović" in Novi Sad in December 2012.

### Anthropometric measures

Physical characteristics, including the measures of body height and body mass, were recorded on the test day. All of the measures were taken from the participants who were dressed in gymnastics leotards and were barefoot. Body height was measured to the nearest 0.1 cm. Body mass was measured with a digital scale for body composition Omron BF511.

### Balance tests

*Balance Error Scoring System.* The postural performance of the participants was measured using the BESS. The BESS is a valid and reliable measure of postural stability and comprises six stance conditions: double-leg, single leg, and tandem stances on both legs, on the firm and foam surface (Riemann & Guskiewicz, 2000). After the instruction, each participant was given two familiarization trials on each condition before the actual data collection. The participant remained as still as possible; if she moved from the test position, he was to return to it as soon as possible. The number of errors for each of the three tests was observed and recorded for the participant's BESS score. A higher score on the BESS indicates poor postural control. All of the participants and all the trials were scored by one examiner. For this investigation, we chose three positions on the firm surface.

*Specific static-balance tests* were measured by using basic gymnastics elements on the balance beam. For the recognition of these elements by the regulation of Code of Points (FIG, 2013), it is necessary to hold the position for two seconds, while the test lasts for ten seconds. Tests were performed on the balance beam, and trials were captured with a Casio FX camera, positioned four meters from the balance beam. Gymnasts performed the scale (SSRV), handstand (SSSU), and handstand in a side position (SSSB). After receiving

instruction, each participant was given two familiarization trials on each condition before the actual data collection. When a participant was ready, she performed the task, while the examiner measured and stopped the test after 10 seconds. If the respondent fell from the beam, she has no right to continue the performance, but the time of the element endurance was recorded. The test score is the sum of points given during the endurance attitude (0-6 points) and technique (0-4 points). The performance of the tests was filmed by a camera, and then the videos were assessed with the help of an expert committee. Table 1 shows errors during execution of the elements and Table 2 shows technical mistakes during the performance. The points for each of the three tests were observed and recorded for the participant's score.

**Table 1** Scoring of the specific static-balance tests; Holding positions (6.00 points)

| Holding position in seconds | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Points | 0.6 | 1.2 | 1.8 | 2.4 | 3 | 3.6 | 4.2 | 4.8 | 5.4 | 6 |

**Table 2** Scoring of specific static-balance test; Technical mistakes (4.00 points)

| Mistake | 0.10 | 0.30 | 0.50 | 1.00 |
|---|---|---|---|---|
| Bent arms or legs | x | x | x | |
| Body position | x | x | | |
| Leg separation | x | x | | |
| Extra arm swing | x | | | |
| Additional body movements to maintain balance | x | x | | |
| Additional hop or jump | x | | | |
| Long step or jump | | x | | |
| Deviation from the course | x | | | |
| Insufficient split 180° | 0-20° | 20-45° | >45° | |
| Pause between the elements | | | x | |
| The grip of the beam to avoid the fall | | | x | |
| Additional movements to maintain balance | x | x | x | |
| Fall | | | | x |

*The YBT* (Y Balance Test) is a measure of dynamic balance in unilateral stance that has been deemed to be reliable and valid. The participant reaches forward with one foot in the anterior, posteromedial, and posterolateral direction. The test is performed barefoot. Following the protocol, each participant was required to perform six practice trials before the three data-collection trials. With the stance-foot toes directly behind the start line, the participant was instructed to reach as far as she could while maintaining balance. Each of the participants was instructed that any of the following activities would constitute a failed attempt, after which an additional trial would be performed: (1) maximal reach with the free leg before the controlled return to the stance platform (2) using momentum (kicking) to move the reach indicator, (3) stepping on the top of the reach indicator for support, or (4) losing balance before the controlled return to the bilateral stance. The amount of rest time between trials was long enough for the rater to record the reach distance and return the indicator to its starting position. All raters were trained in performing the YBT protocol. The reach distance in each direction was normalized to the limb length (i.e. inferior anterosuperior iliac spine to inferior medial malleolus). The sum of three normalized reach distances was then averaged and multiplied by 100 to generate a composite score.

*Specific dynamic-balance tests* were measured using basic gymnastics elements on the balance beam: two 360° turns (SDOU), two jumps of 180º (SD2O) and two cartwheels (SD2Z). The tests were performed on the balance beam, and trials were captured with a Casio FX camera, four meters from the beam. After instruction, each participant was given two familiarization trials on each condition before the actual data collection. When a participant was ready, she performed the task. Performance of the test was filmed by the camera, and then the video was assessed with the help of an expert committee. Table 3 shows errors in the execution of elements. The points for each of the three tests were observed and recorded for the participant's score.

**Table 3** Scoring of specific-dynamic balance tests

| Mistakes | 0.10 | 0.30 | 0.50 | 1.00 |
|---|---|---|---|---|
| Bent arms or legs | x | x | x | |
| Body position during movement | x | x | | |
| Leg separation | x | x | | |
| Additional arm swing | x | | | |
| Body movements to avoid fall | x | x | | |
| Additional jump or step | x | | | |
| Long step or jump | | x | | |
| Deviation from the course | x | | | |
| Insufficient split 180° | 0-20° | 20-45° | >45° | |
| Pause between the elements | | | x | |
| The grip of the beam to avoid the fall | | | x | |
| Additional movements to maintain balance | x | x | x | |
| Fall | | | | x |

**Statistical analyses**

All of the analyses were performed using SPSS 16.0 for Windows (SPSS Inc., Chicago, IL). We calculated the descriptive and comparative statistics. For the descriptive statistics we used the mean value (Mean), standard deviation (SD), and standard error (Std. Error). For comparative statistics, we used the *t*-test for small independent samples (value of the *t*-test – t value, significance of the *t*-test – p.

## RESULTS AND DISCUSSION

The results of both the static and dynamic tests are listed in Table 4. There were no significant differences in the double-leg (SRSU) and tandem stances (SRIZ) and also in specific balance tests SSRV and SSSB. There were significant differences only in the one-leg stance (.021) and specific static balance test SSSU (.000). These results were expected because the older gymnasts scored better results on demanding tests such as the one-leg stance and handstand on the balance beam. These results support the definition that balance depends on age.

In the dynamic balance tests, there were significant differences in the performance of the SD2Z test between the two groups (p=.043). This finding is not so surprising considering that older gymnasts perform more complex acrobatic elements in their routines. The mean start value (DSCO) of the exercise for Group 1 gymnasts during the competition

was 2.95±1.13 points and for Group 2 gymnasts 3.66±.85 (p=.018). The competition rules were the same for both groups of gymnasts and in accordance with FIG Code of points for seniors. There were no significant differences in E score (ESCO) and Final score (FINS).

**Table 4** Means, Standard Deviations and *t*-test results for balance tests of Group 1 (n=22) and Group 2 (n=26) of young gymnasts

| Balance tests | Group 1 (Mean ± SD) | Group 2 (Mean ± SD) | t | p |
|---|---|---|---|---|
| BESS | 9.00 ± 1.15 | 8.45 ± 1.21 | 1.57 | .123 |
| SRSU | .41 ± .59 | .35 ± .56 | .38 | .707 |
| SRJN | 4.32 ± 1.04 | 3.58 ± 1.10 | 2.38 | .021* |
| SRIZ | 4.27 ± 1.16 | 4.54 ± 1.39 | -.71 | .481 |
| SSRV | 8.04 ± .71 | 8.4 ± .76 | -1.68 | .10 |
| SSSU | 5.63 ± 1.66 | 7.53 ± 1.18 | -4.61 | .000* |
| SSSB | 5.16 ± 1.9 | 5.95 ± 2.0 | -1.39 | .171 |
| YBTD | 79.09 ± 6.01 | 80.89 ± 4.88 | -1.14 | .258 |
| YBTL | 80.96 ± 7.04 | 80.16 ± 5.0 | .462 | .646 |
| SDOU | 8.17 ± 1.14 | 8.65 ± .71 | -1.77 | .083 |
| SD2O | 8.25 ± 1.03 | 8.26 ± 1.03 | -.02 | .980 |
| SD2Z | 8.21 ± 1.25 | 8.81 ± .72 | -2.086 | .043* |
| DSCO | 2.95 ± 1.13 | 3.66 ± .85 | -2.45 | .018 |
| ESCO | 6.33 ± 1.34 | 6.64 ± 1.17 | -.855 | .397 |
| FINS | 9.29 ± 2.28 | 10.30 ± 1.45 | -1.88 | .069 |

Our static balance scores for Group 1 and 2 (9.00±1.15, 8.45±1.21, respectively) matched closely with the static balance scores reported by Bressel et al. (2007), the study which included soccer and basketball players and gymnasts (9.1±1.1). Female basketball players demonstrated inferior static balance compared with the gymnasts, and inferior dynamic balance compared with the soccer players. No differences were noted between the gymnasts and soccer players. The authors noted that the statistical differences observed among different sports may be related to the unique sensor-motor challenges imposed by each sport. For example, gymnasts often practice motionless balance skills on the balance beam, similar to skills required in the BESS. Hence, gymnasts may develop superior attention focus on cues that alter balance performance, such as small changes in joint position and acceleration.

According to recent studies (Aydin et al., 2002; Bressel et al., 2007; Assemani et al., 2008) gymnasts have superior static balance on one leg, and better dynamic balance on both feet (Davlin, 2004), but inferior static balance on both feet (Assemani et al., 2008; Bressel et al., 2007; Aydin et al., 2002). In comparative studies, it is important to note that the normalization of the balance scores in relation to height and length of the limbs must be taken into account when comparing the groups with notable differences in the body composition (Bressel et al., 2007).

Gymnastics' landing, which requires maintaining balance after performing very complex elements (floor, beam and lands on the other gymnastic apparatus) influence the development of superior balance compared to other sports.

Atilgan et al. (2012) in a sample of 19 female gymnasts (aged 14.53 ± 2.20) examined the relationship between the loss of balance and the routine given on the balance beam, and the anthropometric characteristics and the tests of static and dynamic balance. They found a negative correlation between the parameters of dynamic balance and age, experience,

physical training and anthropometric variables, while there was no correlation between the parameters of static and dynamic balance and the loss of balance during a series on the beam ($p > 0.05$). The authors concluded that the balance ability of gymnasts is equal during competition and during tests in the laboratory.

Exercising on the balance beam includes balancing in positions (hand support and various feet stands), movements and transitions on the beam, and landing on and off the beam, which means that the specific tests applied in this study are in alignment with the requirements of the balance beam. The fact is that for maintaining a position, the optimal angle between the body segments and muscle tone is important, in order to counter the forces of the body that tend to disturb the balance. In practicing on the balance beam, setting the foot area on the beam is very important. At hand support, the maintenance of balance is regulated by the increased grip. During complex gymnastic movements, the mechanisms associated with the laws of body movements in space are used. Keeping the direction of the movement is essential for success. A minimum of compensatory body movements are essential to maintain balance in order to bring the center of gravity of the body above the support surface. If these movements are emphasized and accompanied by additional hand, legs, and torso movements in order to prevent the fall of the apparatus, they are sanctioned by the judges in competitions.

## CONCLUSIONS

The goal of this study was to compare the balance ability between two age groups of young gymnasts. This study confirms the conclusion that balance ability is related to the competition level when speaking about sports with high balance demands, but this can be applied to more complex tasks, because gymnasts practice elements with the components of balance from an early age. For the top overall results in the Women's Artistic Gymnastics, it is necessary to achieve good results on the balance beam. This discipline is, due to its specific characteristics, different from other women's apparatuses (the vault, uneven bars and the floor). The reduced support surface, among other capabilities, requires a high level of balance. Monitoring balance ability in young categories is important for the future success of gymnasts.

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# RAVNOTEŽA MLADIH GIMNASTIČARKI: RAZLIKE IZMEĐU UZRASNIH KATEGORIJA

*Cilj ovog istraživanja bio je da se utvrde razlike u ravnoteži i uspehu na gredi između mladih gimnastičarki, internacionalnog nivoa takmičenja. U istraživanju je učestvovalo 48 gimnastičarki podeljenih u dve uzrasne grupe (Grupa 1: n=22, starosti 9.0 ± 1.1 godina, telesne visine 136.0 ± 7.6 cm, težine 30.8 ± 4.3 kg; Grupa 2: n=26, starosti 12.1 ± 0.6 godina, telesne visine 146.0 ± 7.0 cm, težine 36.9 ± 6.6 kg). Za utvrđivanje statičke ravnoteže, ispitanice su izvodile tri različita stava na tvrdoj podlozi i tri specifična gimnastička testa ravnoteže, sastavljena od gimnastičkih elemenata na gredi (vaga, stav u uporu i bočni stav u uporu). Za utvrđivanje dinamičke ravnoteže ispitanice su izvodile maksimalne dohvate nogom u tri pravca u stavu na jednoj nozi (Y – test ravnoteže) i tri specifična testa dinamičke ravnoteže, sastavljena od veze dva gimnastička elementa (okret u usponu za 360°, skok sa okretom za 180° i premet strance). Utvrđena je statistički značajna razlika samo kod stava na jednoj nozi (.021) i specifičnog testa statičke ravnoteže (.000). U testovima dinamičke ravnoteže utvrđena je statistički značajna razlika samo kod izvođenja dve zvezde (p=.043). Rezultati istraživanja pokazali su da starije gimnastičarke postižu bolje rezultate kod zahtevnijih položaja i testova, kao što su stav na jednoj nozi, stav u uporu i premet strance na gredi. Postizanje vrhunskih rezultata u ženskoj sportskoj gimnastici zavisi i od rezultata na gredi, stoga je neophodno pratiti sposobnost ravnoteže od najranijeg uzrasta.*

Ključne reči: *sportska gimnastika, greda, statička ravnoteža, dinamička ravnoteža*.