International Journal of Health Sciences and Research
DOI: https://doi.org/10.52403/ijhsr.20210830
Vol.11; Issue: 8; August 2021
Website: www.ijhsr.org
Original Research Article *ISSN: 2249-9571*

Assessment of Static and Dynamic Balance in Swimmers

Kunal Varma[1], Priyanka Gokhale[2]

[1]Physiotherapist, DPO's NETT College of Physiotherapy, Thane, Maharashtra, India.
[2]Assistant Professor DPO's NETT College of Physiotherapy, Thane, Maharashtra, India.

Corresponding Author: Kunal Varma

ABSTRACT

Background: Swimming can be defined as an activity in which a person practices a regulated Olympic sport in order to move as fast as possible through the water due to the propulsive forces generated by arm, leg, and body movements overcoming the resistance of water. Swimming is performed in either a supine or prone position with a bilaterally-symmetric motion and is influenced by buoyancy. In other words, it is nearly unaffected by gravity and requires the same muscle exertion of both the right and left extremities. Balance is considered to be an important component of motor performance tasks. It is controlled by the central nervous system with the help of input from the visual, tactile, proprioceptive and vestibular systems (5) Balance can be defined as a condition during which the body's center-of-gravity (COG) is maintained within its base of support (BOS).
Methodology: In this study, 50 Competitive swimmers were included. 36 Male and 14 Female, with a mean age, height and weight of 22.68 years, 175.56 cm and 70.94 kg respectively. Each had a swimming career more than 5 years, Training at least 5 days a week for 2 hours or more with an average of 10.12 years, 5.54 days a week for 2.68 hour training sessions. Static Balance was assessed using Balance Error Scoring System where the subjects were asked to stand with their eyes closed for 20 seconds in 6 Different Positions and the numbers of errors made were noted. Dynamic Balance was assessed using Star Excursion Balance Test were, a Star was marked on the ground to have 8 directions. The subject stood in the center of the star and had to reach as far as they could in each direction. This distance from the middle to the point of contact of their toe was noted and relative distance was calculated using Limb Length. The Results of both the test was compared with the normal data present.
Result: The result of the test done to evaluate static balance; BESS showed that out of 50 participants 19 had superior balance, 18 had above average balance and 13 had broadly normal balance and the errors on the firm surface and soft surface had a mean and standard deviation of 2 ± 1.12 and 4.1 ± 1.31 respectively. On the other hand, the test done to evaluate dynamic balance; SEBT showed that in each direction on an average the swimmer could reach 119.21 ± 8.39 % relative distance in each direction.
Conclusion: Different tests were conducted in the study to understand if competitive swimmers are somehow weak in terms of static and dynamic balance. The entire study is based on the effectiveness of maintaining and enhancing the static and dynamic stability among the swimmers. This study concludes that competitive swimmers have Superior Static and Dynamic Balance because of strong core muscles used to keep their body streamlined during swimming and good flexibility and neuromuscular feedback.

Keywords: Balance, Swimmers, Star Excursion Balance test (SEBT), Balance Error Scoring System (BESS).

INTRODUCTION

Swimming can be defined as an activity in which a person practices a regulated Olympic sport in order to move as fast as possible through the water due to the propulsive forces generated by arm, leg, and body movements overcoming the resistance of water. [1]

There are four competitive swimming strokes: (i) Freestyle; (ii) Back stroke; (iii) Breast stroke and; (iv) Butterfly. [2] In freestyle, butterfly, and backstroke there are two phases of the stroke: the pull-through and the recovery. Pull-through involves adduction and internal rotation of the shoulder as the elbow flexes and then extends. The recovery phase involves abduction and external rotation of the shoulder again, followed by elbow flexion and then extension. [3]Swimming is performed in either a supine or prone position with a bilaterally-symmetric motion and is influenced by buoyancy. In other words, it is nearly unaffected by gravity and requires the same muscle exertion of both the right and left extremities [4]

The role of kicking is to Provide Propulsion and stabilizes the body in water. [4] Swimming repeats symmetrical movement, and both legs are used equally. Intensive training refers to one or two daily workouts of two- or four-hours duration, seven days a week for most part of the year. [9] More than three quarters of all competitive swimming events are completed in less than two and a half minutes by athletes of at least national level. To prepare for these events, coaches manipulate training load (usually described as a combination of volume, intensity, frequency, and dry-land training) at various times of the season in an attempt to prepare their swimmers to peak just at the right time. In view of an upcoming competition, there is usually a phase of high load training followed by some kind of tapering (reduced load) program. [10]

Balance is considered to be an important component of motor performance tasks. It is controlled by the central nervous system with the help of input from the visual, tactile, proprioceptive and vestibular systems [5] Balance can be defined as a condition during which the body's center-of-gravity (COG) is maintained within its base of support (BOS) [6]

Static balance is defined as maintaining postural equilibrium while holding the body in a stationary position whereas Dynamic balance is maintenance of postural equilibrium while distal/proximal parts of the body are moving [5]

Athletic trainers often prescribe exercises in an attempt to enhance an athlete’s postural control or balance and perhaps reduce the risk of injury. Unipedal balance tasks on progressively challenging surfaces (e.g., firm floor to ankle disc) are examples of exercises that have improved the balance of athletes after ankle sprains.

Differences in ankle and knee proprioception between trained athletes and matched controls suggest that sport participation, by challenging sensorimotor systems, may enhance balance. Each sport likely requires different levels of sensorimotor processes to perform skills and protect the neuromuscular system from injury [11]

One Leg Stance (OLS), Modified Star Excursion Balance Test (SEBT), Timed Up and Go test (TUG), and 10-m walk test are some of the common tests used to assess balance [12]

MATERIALS AND METHODS

This study was a cross sectional observational study where 50 competitive swimmers were selected using convenient sampling. Inclusion criteria: Subjects willing to participate, the subjects in this study were both males and females, the age group of 18-30 years including that they had experience of more than 5 years and worked an average of 2 hours of training per day for at least 5 days in a week.Swimmers having any recent musculoskeletal injuries or deformities and or having any neurological problems were excluded from the study.

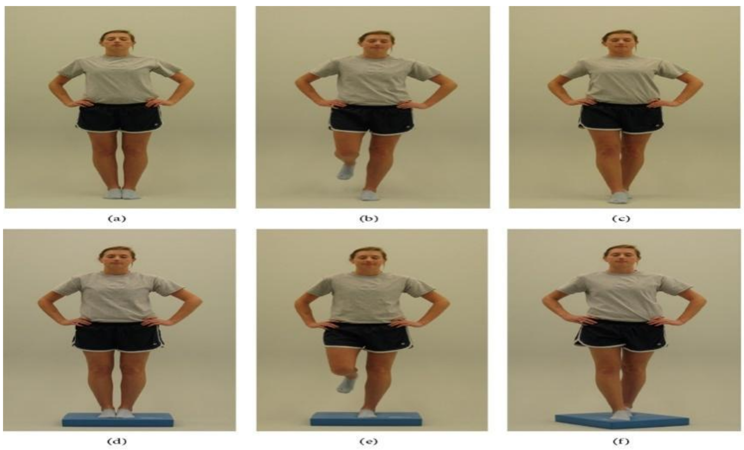
PROCEDURE:

TO ASSESS STATIC BALANCE: Static balance was assessed using Balance Error Scoring System

This test consisted of 6– 20 second tests with three different stances on two different surfaces

The subjects were instructed to perform the following tests barefoot, hands on hips, eyes closed, for 20s each. The subjects were instructed to attain and maintain the following positions for twenty seconds – Double leg stance with feet together on foam pad, Double leg stance with feet together on firm surface, Single leg stance on non-dominant foot on foam pad, Single leg stance on non-dominant foot on firm surface, Tandem stance (one foot in front of the other, dominant foot in back) on foam pad, Tandem stance (one foot in front of the other, dominant foot in back) on firm surface. Each of the trial was scored by counting the errors, or deviations from the proper stance, accumulated by the subject. The counting of errors was started only after the individual has assumed the proper testing position

Errors in BESS: An error was credited to the subject when any of the following occurred: Moving the hands off of the iliac crests, Opening the eyes, Step stumble or fall, Abduction or Flexion of the Hip beyond 30°, Lifting the forefoot or heel off of the testing surface. The maximum number of errors for each position is ten.



TO ASSESS DYNAMIC BALANCE: Dynamic balance was assessed using Star Excursion Balance Test.

A sticky tape was stuck 4 - 120cm lengths on to the floor, intersecting in the middle, and with the lines placed at 45^{O} angles, making a Star. The subject was asked to stand in the center of the star. With their hands firmly placed on their hips, the subject was then instructed to reach with one foot as far as possible and lightly touch the line before returning back to the starting upright position. With a marker, the spot at which the athlete touched the line with their toe was marked. They were then be asked to repeat this with the same foot for all reach directions before changing foot. After the subjects completed a full circuit (every reach direction) with each foot, they were then be asked to repeat this process for a total of three times per leg. The reach distance of each successful attempt, was marked with a marker, in order to calculate the athlete's SEBT score after the test.

Failed attempts include the following: The subject unable to touch their foot down on the floor before returning back to the starting position. Any loss of balance will result in a failed attempt. The subject unable to hold onto any implement to aid their balance. The subject must keep their hands on their hips at all times throughout the test. The subject must lightly touch their toe on the reach line whilst staying in full control of their body. Any loss of balance resulting in a heavy toe/foot contact with the floor should be regarded as a failed attempt.

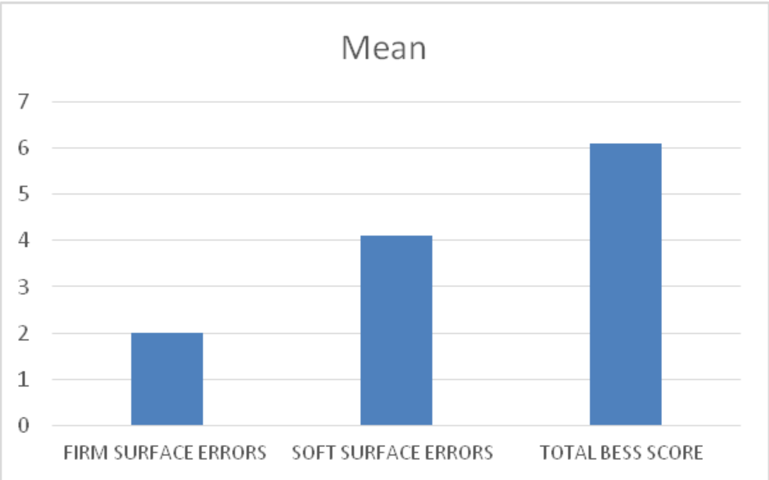
MATERIALS: Foam Pad - Dimensions: Length: 10” Width: 10” Height: 2.5”, Stop watch. BESS Score Card, Stick tape (minimum 8 meters), Measuring tape, Performance recording sheet.

STATISTICAL ANALYSIS: Collected data was entered in Microsoft Excel and was used for the data analysis. The statistical significance of difference for the majority is tested using One-sample Chi-Square test by considering expected frequency of scores (both BESS and SEBT) to be 50%. In the entire study, the p-values less than 0.05 are considered to be statistically significant. The entire data is statistically analysed using Statistical Package for Social Sciences (SPSS version 22.0, IBM Corporation, USA) for MS Windows.

Table 1: The Mean and Standard deviation (SD) for demographic data- age, height, weight, experience, days/week, duration of training.

DATA	MEAN & SD
GENDER	MALE = 36, FEMALE = 14
AGE (YEARS)	22.68 ±2.84
HEIGHT (CM)	175.56±4.28
WEIGHT (KG)	70.94 ±8.14
EXPERIENCE (YEARS)	10.12 ±4.48
DAYS / WEEK	5.54 ±0.61
DURATION (HOURS)	2.68 ±0.705372965

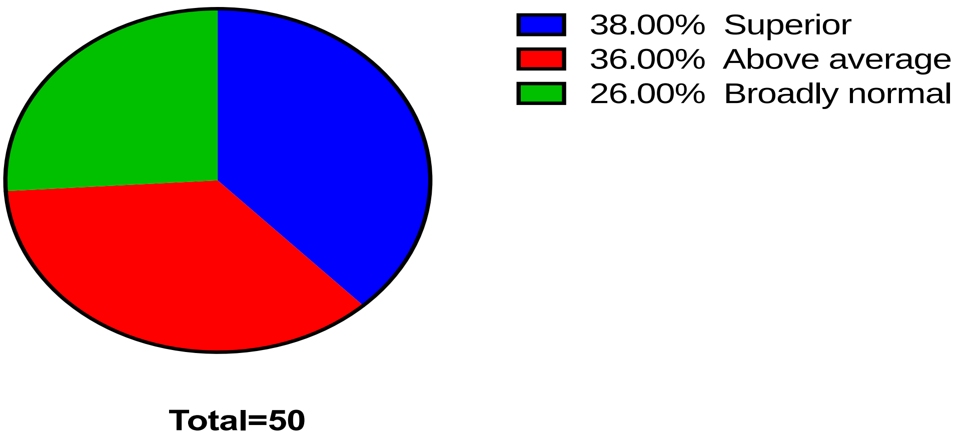
Balance Error Scoring System:



Graph 1: The Mean BESS DATA – Firm surface errors, Soft surface errors, Total BESS score.

Table 2: The Mean, Standard deviation, Chi-Square Value & P-Value for the BESS Data. Statistical Testing was done Using One-Sample Chi Square Test.

	Mean	Standard Deviation	Chi-Square- Value=	P- Value
FIRM SURFACE ERRORS	2	1.124858268	46.080	0.001 (Statistically Significant by chi-Square test).
SOFT SURFACE ERRORS	4.1	1.313198308		
TOTAL BESS SCORE	6.1	1.823578708		



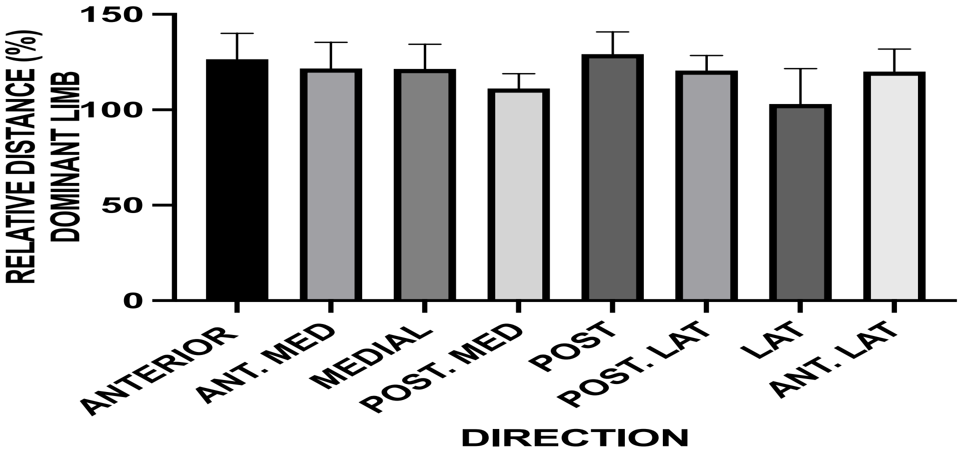
Graph 2:The total percentage of Participants and their classification according to the Total BESS Score.

Table 3: The Classification, BESS Score range and Total number of participants.

Classification	BESS Score	No. of Participants
Superior	0-5	19
Above Average	6-7	18
Broadly Normal	8-14	13
Below Average	15-17	0
Poor	18-23	0
Very Poor	24+	0

The Recorded data was assessed with the Normal data present and statistical analysis was performed. Of 50 participants, all i.e. 50 (100.0%) had Broadly Normal to Superior BESS Score and none had Below average to Very poor BESS score in the study group. Significantly higher proportion of participants had superior static balance in the study group with P-value<0.001 hence the data is Statistically Significant.

Star Excursion Balance Test :



Graph 3: The Mean Relative distance (%) for each direction.

Table 4: The Mean & Standard deviation (SD) for Relative Distance % in each direction of the SEBT, Chi-Square Value, P-Value.

	Mean	Standard Deviation	Chi-Square-Value=	P-Value=
Anterior	126.52	13.51377226	3.920	0.048 (Statistically Significant by chi-Square test).
Anteromedial	121.74	13.56738286		
Medial	121.46	12.90342464		
Posteromedial	111.2	7.70634512		
Posterior	129.22	11.63964022		
Posterolateral	120.52	7.928867433		
Lateral	103.02	18.4904719		
Anterolateral	120.06	11.81387977		

Interpretation:

The Recorded data of all the participants was analysed using a One Sample Chi- Square Test. Significantly higher proportion of participants had Superior dynamic balance in the study group with a P-Value<0.05 hence the data is Statistically Significant

RESULT

The result of the test done to evaluate static balance; BESS showed that out of 50 participants 19 had superior balance, 18 had above average balance and 13 had broadly normal balance and the errors on the firm surface and soft surface had a mean and standard deviation of 2 ± 1.12 and 4.1 ± 1.31 respectively. On the other hand, the test done to evaluate dynamic balance; SEBT showed that in each direction on an average the swimmer could reach 119.21 ± 8.39 % relative distance in each direction. The Recorded data of all the participants was compared with the Normal data present & analyzed using a One Sample Chi- Square Test. Of 50 participants, all i.e. 50 (100.0%) had Broadly Normal to Superior BESS Score with P-value<0.001. For SEBT Significantly higher proportion of participants had Superior dynamic balance in the study group with a P-Value<0.05 hence the data is Statistically Significant.

DISCUSSION

Swimming can be defined as an activity in which a person practices a regulated Olympic sport in order to move as fast as possible through the water due to the propulsive forces generated by arm, leg, and body movements overcoming the resistance of water. [1] It is an organized, fast growing sport with competitive swimmers found in abundance in all age groups. Included are those athletes who compete in formal events and competitions at District, State, National and International Levels. [2] This sport is unique in that it provides upper and lower body strength and cardiovascular training, which is performed in a non-weight bearing environment. [2]

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, the vestibular system, somatic sensation, and leg strength. 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. However, the exertion is not always necessary when swimming due to effects of buoyancy[3]As a result of the widespread participation, the long training hours inside water i.e. A non-weight bearing environment, the need to investigate balance in these groups is evident.

This study examines the static and dynamic balance abilities in competitive swimmers. In this study, 50 Competitive swimmers were included. 36 Male and 14 Female, with a mean age, height and weight of 22.68 years, 175.56 cm and 70.94 kg respectively. Each had a swimming career more than 5 years, Training at least 5 days a week for 2 hours or more with an average of 10.12 years, 5.54 days a week for 2.68 hour training sessions.

Static Balance was assessed using Balance Error Scoring System while Dynamic Balance was assessed using Star Excursion Balance Test.

Competitive swimmers stay in the water for a long period of time. It is a hypothesis that it results in inferior static balance. However, the data gathered form the test showed otherwise. The reason behind selecting the hypothesis that the swimmers will have an inferior static balance is based on the reason that they have to stay in water for longer period of time for the training purposes. Therefore, they would have less usage of the antigravity muscles compared to the normal population.

A similar study conducted by Hiroki Sugiura. et. al in which they evaluated Static balance and dynamic balance by the centre sway of foot pressure and stability on an unstable stool, respectively between the swimmers and general student group. No significant difference was found in the static balance assessed by the centre of foot pressure between competitive swimmers and general students. However, dynamic balance is superior in competitive swimmers than in general students. [14]

In this study, a similar method was used to evaluate the participants Balance. As a result, significantly higher proportion of participants had superior Static balance in the study (P-value<0.001). & significantly higher proportion of participants had superior Dynamic balance in the study (P-value<0.05).

The Star Excursion Balance Test indicated that the swimmers have a higher range of dynamic balance compared to the normal population. Jadcaz *et al.* in a similar study mentioned that the complex position of the test has resulted in more usage of the core and supporting muscles. The results indicate that swimmers are ahead in terms of the dynamic balance. This is similar in terms of limb coordination as well. [15]

As mentioned by Stawicki *et al.*, it is essential for swimmers to put more attention towards the somatosensory factors such as physical position or the water resistance. Furthermore, the experience of competing has resulted in a superior somatosensory function for the swimmers. (16)

According to Shimojyo et al., 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 are considered to have superior somatosensory function. (17)

In a similar study, Emura and Matsuura et al. 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 population. (18)

A similar study by Matsuda et al. examined static balance among soccer players, basketball players, swimmers, and non-athletes, and reported no significant difference between swimmers and non-athletes. (19) 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 BESS Test easily. It was reported that laterality was not found in static balance for the one-leg stand in soccer players, basketball players, swimmers, and non-athletes. 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, However Seifert et al. in another study reported that expert swimmers are superior in their limb coordination and hence can have a superior balance. (20)

The BESS score of 14 can be termed as the applicable outcome of the null hypothesis. However, the BESS score conducted provided a result ranging up to 10. This also indicates that the swimmers have Broadly Normal to Superior levels of balance and therefore the null hypothesis can be neglected. (21)

From all the previous studies done we can say that Core strength is needed to maintain proper posture, balance, and alignment in the water. If these elements are not maintained, then resistive forces will increase and stroke technique will break down, leading to an inefficient stroke. Increasing the core strength of a swimmer will improve his or her ability to maintain efficient technique throughout the entire race

Maintaining a streamlined body position and balance is one of the critical factors in improving the efficiency of a swimmer’s performance, which in turn depends on the strength of the core muscles. Unlike other ground based sports swimming has no ground pushing back to limit the way in which the body can move and adjust the centre of gravity to maintain balance, and therefore the core muscles have to be as strong as possible to carry out similar functions of balance and movement in water. (22)

Studies show that the key to swimming fast, efficiently, and strong is to maximize balance in the water and minimize drag. While most of our weight is located in our hips and lower body, this often leads to a diagonal line in the water, meaning that athletes literally have to drag their body through the water. In order to minimize this drag, the swimmers have to activate and use their core muscle strength to keep their body in a streamlined position. This will decrease drag and increase swim speed.

Studies have also proven that there is a strong positive correlation between core muscles strength, buoyancy and finally swimming performance. Where sport specific skills are concerned, an athlete’s core acts as a foundation of movement generation and power production leading to an improvement in the performance. A strong core enables an athlete to execute more efficient and swift body movements thereby leading to a better force distribution from the fully developed core to the upper and lower body region. [23]

A study conducted by QU Ping. et. al. in order to investigate the effect of core training on dynamic stability competency on elite swimming athletes by Star Excursion Balance Test found that core training and stability can significantly improve coordination of vestibular perception, somatosensory, vision, central nervous system of regulation, muscle strength, resistance to external interference and quick action of fin swimmers, thereby enhance balance and be an important factor while assessing balance in competitive swimmers. [24]

This proves that Balance control relies on rapid and continuous feedback from visual, vestibular, and sensory systems to execute smooth and coordinated neuromuscular actions. Swimming is fundamentally different from other weight-bearing activities. Studies have proven that Swimmers must maintain a horizontal body position in the water to avoid drag by using their core muscles (e.g., erector spinae, rectus abdominis, and iliopsoas). Which increases strength and therefore leads to improved balance in competitive swimming athletes. Another possible neuromuscular benefit of swimming is the need to use foot movements of various styles, which may improve the force of ankle dorsiflexion which can be the cause of the outcome of this study. Further research needs to be done on the Ankle and Foot range of motion of competitive swimmers to find the exact cause of increased ankle dorsiflexion in swimmers.

CONCLUSION

Different tests were conducted in the study to understand if competitive swimmers are somehow weak in terms of static and dynamic balance. The entire study is based on the effectiveness of maintaining and enhancing the static and dynamic stability among the swimmers. This study concludes that competitive swimmers have Superior Static and Dynamic Balance because of strong core muscles used to keep their body streamlined during swimming and good flexibility and neuromuscular feedback

Acknowledgement: None

Conflict of Interest: None

Source of Funding: None

REFERENCES

1. Escalante Y, Saavedra J. Swimming and aquatic activities: state of the art. Journal of human kinetics. 2012 May 1;32:5-7.
2. Barbosa TM, Marinho DA, Costa MJ, Silva AJ. Biomechanics of competitive swimming strokes. Biomechanics in applications. 2011:367-88.
3. Peter Brukner and Karim Khan. Clinical sports medicine 4th edition; Pg: 105
4. Demura, S. , Aoki, H. , Yamamoto, Y. and Yamaji, S. (2010) Comparison of strength values and laterality in various muscle contractions between competitive swimmers and untrained persons. Health, 2, 1249-1254. doi: 10.4236/health.2010.211185.
5. Jaffri AH, Newman TM, Smith BI, Miller SJ. The dynamic leap and balance test (dlbt): a test-retest reliability study. International journal of sports physical therapy. 2017 Aug;12(4):512.
6. Blackburn T, Guskiewicz KM, Petschauer MA, Prentice WE. Balance and joint stability: the relative contributions of proprioception and muscular strength. Journal of sport rehabilitation. 2000 Nov;9(4):315-28.
7. Sugiura H, Demura S, Kitabayashi T, Shimoyama Y, Sato D, Xu N, Asakura Y. Characteristics of Static and Dynamic Balance Abilities in Competitive Swimmers. American Journal of Sports Science and Medicine. 2014;2(6):208-11.
8. Yanai T. Buoyancy is the primary source of generating bodyroll in front-crawl swimming. Journal of Biomechanics. 2004 May 1;37(5):605-12.

9. Hogg JM. Intensive swimming training for the young. British journal of sports medicine. 1973 Dec;7(3-4):375.\
10. Chatard JC, Mujika I. Training load and performance in swimming. Biomechanics and medicine in swimming VIII. 1999:429-34.
11. Bressel E, Yonker JC, Kras J, Heath EM. Comparison of static and dynamic balance in female collegiate soccer, basketball, and gymnastics athletes. Journal of athletic training. 2007 Jan;42(1):42.
12. Hemmati L, Rojhani-Shirazi Z, Malek-Hoseini H, Mobaraki I. Evaluation of static and dynamic balance tests in single and dual task conditions in participants with nonspecific chronic low back pain. Journal of chiropractic medicine. 2017 Sep 1;16(3):189-94.
13. Han SK, Kim MC, An CS. Comparison of effects of a proprioceptive exercise program in water and on land the balance of chronic stroke patients. Journal of physical therapy science. 2013;25(10):1219-22.
14. Sugiura H, Demura S, Kitabayashi T, Shimoyama Y, Sato D, Xu N, Asakura Y. Characteristics of static and dynamic balance abilities in competitive swimmers. American Journal of Sports Science and Medicine. 2014 Nov 11;2(6):208-11.
15. Jadczak Ł, Grygorowicz M, Wieczorek A, Śliwowski R. Analysis of static balance performance and dynamic postural priority according to playing position in elite soccer players. Gait & posture. 2019 Oct 1;74:148-53
16. Stawicki P, Wareńczak A, Lisiński P. Does Regular Dancing Improve Static Balance?. International Journal of Environmental Research and Public Health. 2021 Jan;18(10):5056.
17. Shimojo H, Sengoku Y, Miyoshi T, Tsubakimoto S, Takagi H. Effect of imposing changes in kick frequency on kinematics during undulatory underwater swimming at maximal effort in male swimmers. Human movement science. 2014 Dec 1;38:94-105.
18. Matsuura Y, Matsunaga N, Iizuka S, Akuzawa H, Kaneoka K. Muscle synergy of the underwater undulatory swimming in elite male swimmers. Frontiers in Sports and Active Living. 2020 Jun 3;2:62.
19. Matsuda S, Demura S, Uchiyama M. Centre of pressure sway characteristics during static one-legged stance of athletes from different sports. Journal of sports sciences. 2008 May 1;26(7):775-9.
20. Seifert L, Leblanc H, Chollet D, Delignières D. Inter-limb coordination in swimming: effect of speed and skill level. Human movement science. 2010 Feb 1;29(1):103-13.
21. Iverson GL, Koehle MS. Normative data for the balance error scoring system in adults. Rehabilitation research and practice. 2013 Jan 1;2013.
22. Patil D, Salian SC, Yardi S. The effect of core strengthening on performance of young competitive swimmers. International Journal of Science and Research. 2014;3(6):2470-7.
23. Sharrock C, Cropper J, Mostad J, Johnson M, Malone T. A pilot study of core stability and athletic performance: is there a relationship?. International journal of sports physical therapy. 2011 Jun;6(2):63.
24. Ping Q, Chaoying W, Weitao Z. Application of SEBT on core training measurement on fin swimming athletes. In2011 International Conference on Future Computer Science and Education 2011 Aug 20 (pp. 344-347). IEEE.

How to cite this article: Varma K, Gokhale P. Assessment of static and dynamic balance in swimmers. *Int J Health Sci Res.* 2021; 11(8): 202-210. DOI: *https://doi.org/10.52403/ijhsr.20210830*

******