Annals of International Medical and Dental Research
E-ISSN: 2395-2822 | P-ISSN: 2395-2814
Vol-7, Issue-6 | November-December 2021
Page no- 01-09 | Section- Research Article (Physiotherapy)

Test- Retest Reliability of Y-Balance Test in Collegiate Students

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Received: 29 May 2021
Revised: 26 July 2021
Accepted: 08 August 2021
Published: 22 October 2021

Abstract

Background: Y Balance Test (YBT) is a device which is used to assess dynamic balance and has been used for various purposes including lower limb injury prediction, assessment of post-rehabilitation improvement, analysis of neuromuscular performance and functional effects of training. It has three reach directions Anterior, posteromedial and posterolateral. In order to improve the measurement protocol of the Star Excursion Balance Test (SEBT), the YBT has been developed. **Objectives**: To assess the test-retest reliability, standard error of measurement (SEM), and smallest detectable difference (SDD) associated with the YBT. **Methods**: Maximum reach distances were measured using the YBT in all the three direction on a sample of 20 sedentary collegiate students (10 male, 10 female; age 18-35 years). Intraclass correlations coefficients (ICC), SEM and SDD values were calculated to obtain reliability and measurement error. **Results:** Test-retest reliability for YBT was excellent, with ICCs ranging from 0.93 to 0.95. The values of 95% confidence intervals (CI), SEM and SDD ranged from 0.83 to 0.98, 1.37 to 1.93 and 3.8 to 5.32 %, respectively. **Conclusions:** The YBT is an extremely reliable tool for measuring dynamic balance in collegiate students. Result of the present study substantiates the opinion that change in YBT scores are due to change in an individual's performance and are not due to random error. Changes in normalized scores greater than SDD are needed to confidently ascertain a real change in YBT performance.

Keywords:- Dynamic Balance, Y Balance Test (YBT), Dominant Limb, Limb Length.

INTRODUCTION

The Y Balance Test is a device to assess the dynamic balance of active people, athletes and individuals having musculoskeletal problems.[1,2] Dynamic balance is described as the ability to maintain a stable base of support whilst completing a prescribed movement.[3] This dynamic balance is essential for activities of daily livings, such as walking, jogging, travelling and going up and down the stairs as well as sports specific activities.[4] Balance is maintained by visual, vestibular and somatosensory inputs.[5] Therefore, it may be adversely affected by head injury, aging, and musculoskeletal trauma.[4] Furthermore, impairment of balance is an established risk factor for injuries of lower limbs such as Anterior Cruciate Ligament tears, patellofemoral pain syndrome (PFPS), or instability and sprain of ankle.[6,7,8,9,10]

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However, faster, reliable and field-expedient measures of balance with established discriminant and predictive validity for injuries of lower extremities are limited.[11]

Earlier, the Star Excursion Balance Test (SEBT) was commonly used to evaluate the dynamic balance of sportspersons. The SEBT is performed using single limb stance which needs strength, proprioception, neuromuscular control and flexibility.[12] Past literature suggests that SEBT has been broadly used for numerous purposes which include screening, injury identification and prediction,[10,11,13] training and rehabilitation.[14,15] Although the SEBT is a valid and reliable outcome measure of dynamic balance but a number of limitations are associated with it.

Major difficulty which has been associated with the SEBT is time-taking protocol as in this procedure subjects perform movements in 8 different reach directions.[16] Furthermore, there will be fatigability in stance limb as the subject has to execute total number of 72 reach movements during the entire process.[16] Other problems with SEBT are difficulty in accurate assessment of stance limb movement, the location of starting point for the foot and lack of clearly defined criteria which constitutes a successful reach.

This location of starting point has a wide range of variations as it includes, bisection of the lateral malleolus,[9,17,18,19] tip of the toes,[11] center of the foot and direction of the reach movement.[8,9,20] Hence, these limitations lead to variations in the administration and interpretation of this test protocol.[2] This led to the invention of a new tool, the Y Balance Test (YBT).

The YBT is a modified and developed version of the SEBT, which include only three reach directions viz. anterior, posteromedial (PM), and posterolateral (PL) instead of all 8 reach directions.[2] The device utilizes the anterior, posteromedial (PM), and posterolateral (PL) components of the SEBT. This device and protocol attempts to address the common sources of error and method variation of the previous procedure viz. SEBT. YBT is in use for various purposes including lower limb injury prediction, assessment of post-rehabilitation improvement, analysis of neuromuscular performance and functional effects of training.[11,21,22,23]

The intrarater and interrater reliability of YBT has been established previously by Plisky et al,[2] in soccer players with ICC values 0.85 to 0.89 and 0.99 to 1.00 respectively. In another study, Shaffer, S. W et al., (2013) reported ICC values for interrater reliability from 0.80 to 0.85 on military trainees.[1] They also reported standard error of measurement (SEM) and smallest detectable difference (SDD) of the measurements. The values of SEM and SDD are important as it is helpful to assess previous as well as future research, and actual improvement in performance of an individual after training or a rehabilitation program.

Without these measurement error values, actual differences in performance cannot be assessed appropriately as it will not be possible to ascertain whether these changes are due to measurement errors or from intervention.

Formerly, reliability of the YBT as well as SEBT was evaluated in athletes and various other active populations but on reviewing the English literature on the subject the author did not find any study being conducted to evaluate

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the reliability of the YBT in sedentary healthy collegiate students. Therefore, the current study is conducted to firstly, evaluate the reliability of the YBT in sedentary normal collegiate population and secondly, to establish error scores in order to identify true changes in performance and finally, to evaluate the SDD.

MATERIAL AND METHODS

Twenty collegiate students (10 males, 10 females; age 18-35 years) participated in this study. Demographic description is mentioned in [Table 1]. Subjects were excluded from participation in the study if they had complaint of lower limb or back pain; amputation; any lower extremity surgery or fracture; vestibular disorder; current or undergoing treatment for inner ear; neurological disorder; pregnancy, and history of participation in exercise program or physical training in past 6 weeks. All participants carefully read and signed an informed consent form before the participation in the study.

Testing device (Y Balance Test Kit)

It comprises of a stance platform to which three PVC pipes are attached in the anterior, posteromedial (PM), and posterolateral (PL) reach directions. The pipes are arranged in such a way that the angle between anterior pipe and posterior pipes is 135 degrees; and between the posterior pipes is 90 degrees [Figure 1]. In each pipe, scales with 5 mm increments are marked for measurement. The participant is allowed to push a target (reach indicator) along the pipe that remains over the tape measure till the performance is ended, to make the determination of reach distance more accurate.[2]

Y Balance Test Protocol

All the participants were tested twice at the same time of day at an interval of 72 hours. Prior to the first reading an instructional video was seen by all the participants to understand the procedure.[11] Before the official testing, they practiced 6 trials on dominant leg in each of the 3 directions to achieve a significant learning effect.[16,24] The subjects stood on the foot plate (grid) with dominant leg, placing his most distal aspect of the great toe at the starting line. While sustaining this position, the subjects were advised to reach as maximum as they can with the free limb in the anterior, PM, and PL directions [Figure 2]. Hence, the measurement of the maximal reach distance was taken by tape measure at the edge of the reach indicator. Each participant was instructed to perform the movement in same pattern of rotation (clockwise or anti clockwise) with common starting direction to avoid order effects.[15]

The trial was discarded and repeated, if the participant failed to maintain single limb stance, or if any movement occurred at the fixed stance limb or balance of the reach foot is lost and touched the ground, or the limb could not return to the starting position successfully. The maximum distance out of the 3 trials for each reach direction was used for analysis. Also, the maximum reach distances of all directions were summed up to yield a composite reach distance for analysis of the overall performance on the test.

Lower limb length measurement

The limb length of the participants was measured in centimetres from the anterior superior iliac spine to the medial malleolus in

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supine position with a tape measure after squaring the pelvis.[2]

Data Analysis

Maximal reach distance over 3 trials was analyzed for every subject for the dominant limb in the anterior, PM and PL directions. Since reach distance is linked to length of the lower limb, maximum reach distance was normalized to limb length to allow comparisons across subjects and among studies. The normalized value was obtained as maximum reach distance divided by limb length, then multiplied by 100.[11] The normalized value for composite reach was calculated as composite reach distance, divided by 3 times limb length, then multiplied by 100. Descriptive statistics (means & standard deviations (SD)) were calculated for each reach distance and composite reach distance for dominant limb. The intrarater reliability was evaluated by using an ICC (3, 1).

The grading system used to evaluate ICCs was according to the following standard: Poor = <0.40, Fair = 0.40- 0.70, Good = 0.70- 0.90, excellent > 0.90.[25] The SEM was calculated as: SD (pooled) × √(1−ICC)) whilst SDD was calculated as: 1.96 × √2 × SEM).[26] to assess response stability and precision. Data were analysed with the help of SPSS for Windows, Version 21.0 statistical software.

RESULTS

Mean, SD of the maximum reaches or absolute reach (without normalize) of the dominant limb along with their normalized values in all directions are reported in [Table 2]. The reliability estimates obtained for each of the three normalized reaches and composite (ICC values), 95 % confidence interval (CI), SEM and SDD are presented in [Table 3]. The ICC values for all directions ranged from 0.93 to 0.95 with anterior reach 0.95, PM reach 0.94, PL reach 0.93, and composite 0.96. The values of ICCs, 95 % confidence interval (CI), SEM and SDD of all absolute reaches are provided in [Table 4].

Table 1: Demographics

Type	**Mean ± SD**
Age (years)	23.95 ± 2.64
Height (m)	1.61 ± .03
Weight (kg)	58.10 ± 5.20
Body Mass Index (kg/m2)	22.24 ± 1.55
Limb Length (cm)	88.31 ± 2.34

SD: standard deviation; m: meter; kg: kilogram; cm: centimetre.

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Table 2: Mean and standard deviation of test and retest values

Direction	Initial test		Retest	
	Absolute Mean ± SD	Normalized Mean ± SD	Absolute Mean ± SD	Normalized Mean ± SD
Anterior	60.67 ± 6.09	68.66 ± 6.13	60.65 ± 6.38	68.64 ± 6.63
Posteromedial	91.30 ± 8.07	103.32 ± 7.92	92.60 ± 8.80	104.78 ± 8.72
Posterolateral	87.06 ± 5.90	98.59 ± 6.36	87.20 ± 6.94	98.73 ± 7.28
Composite (Normalized)	239.03 ± 18.77	90.19 ± 6.21	240.45 ± 20.12	90.72 ± 6.68

SD: standard deviation

Table 3: Intrarater reliability for the dominant stance limb for the Y balance test. (Normalized trials of all reach directions)

Direction	ICC (3,1)	95% CI	SEM	SDD (%)
Anterior	0.95	(0.869-0.979)	1.37	3.8
Posteromedial	0.94	(0.848-0.976)	1.93	5.32
Posterolateral	0.93	(0.831-0.974)	1.68	4.66
Composite (Normalized)	0.96	(0.910-0.986)	1.24	3.44

ICC: intraclass correlation coefficient; CI: confidence interval; SEM: standard error of measurement; SDD: smallest detectable difference.

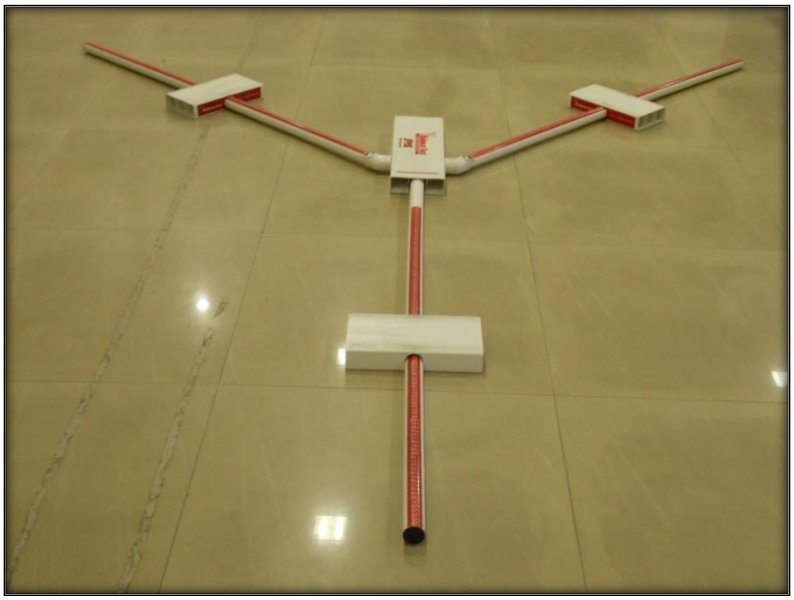

Figure 1: The Y Balance Kit. Figure shows Y balance test device. Three PVC pipes are attached to a stance platform in the anterior, posteromedial (PM), and posterolateral (PL) reach directions. The pipes are arranged in such a way that the angle between anterior pipe and posterior pipes is 135 degrees; and between the posterior pipes is 90 degrees. The participant is allowed to push a target successfully to access the balance.

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Table 4: Intrarater reliability for the dominant stance limb for the Y balance test. (Absolute reaches of all reach directions)

Direction	ICC (3,1)	95% CI	SEM (cm)	SDD (cm)
Anterior	0.96	0.89-0.98	1.22	3.38
Posteromedial	0.95	0.89-0.98	1.80	4.99
Posterolateral	0.94	0.85-0.98	1.44	3.99
Composite	0.97	0.93-0.99	3.25	9.01

ICC: intraclass correlation coefficient; CI: confidence interval; SEM: standard error of measurement; SDD: smallest detectable difference.

Figure 2: Test protocol, Figure shows the process of performing the Y balance test. The subject stands on the foot plate (grid) in the center with dominant leg, placing his most distal aspect of the great toe at the starting line. While sustaining this position, the subject is advised to reach as maximum as he can with the free limb in all the three directions. The measurement of the maximal reach distance is taken by tape measure at the edge of the reach indicator to access dynamic balance.

DISCUSSION

Y Balance Test is a tool which is used to measure dynamic balance, requiring subjects to maintain equilibrium on one limb, while moving the other limb. The ability of maintaining standing position in a normal individual can be described as a state of quasi-static equilibrium. This state is a result of center of mass of the body falling within the base of support (BOS), indicating overall sway without a loss of the base of support. The aim

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of the YBT is to force subjects to alter their equilibrium to a near maximum without a fall and then return back to the state of equilibrium (starting point).

The intrarater reliability of the SEBT has been described as fair to excellent (ICC 0.67-0.97),[4,16,27,28] whereas the interrater reliability as poor to excellent (0.35-0.93).[16] The wide variability in these ranges of reliability of the SEBT advocates the need to improve the accuracy of testing procedures and the importance of a standardized testing protocol. Hence, the YBT was designed to address most of the drawbacks of the traditional SEBT testing methods. Advantage of YBT over SEBT that improves the reproducibility of the measurements include properties such as a reach indicator, standard height of free limb from the ground, clearly explained criteria, and the facility of a mark over the tape measure to record the reach distance when movement is over. These features make the measurements more accurate as the attention of the rater is more on observing the subject, which results in better assessment of movement quality.[2]

Existing literature suggests that SEBT as well as YBT are reliable tools for the assessment of dynamic balance in active younger adults,[29] actively training service members and male collegiate sport persons.[1,2] The present study was conducted on sedentary collegiate students and results indicate that YBT is reliably obtained by same rater across a 72-hours duration. To prevent error from the effect of fatigue and practice effect, the readings of this study were taken on different days. This study has shown reliability scores of the normalized value in present population with excellent ICC's range. According to the present study's normalised SDD values, indicate an actual change in performance, a person should improve by values ranging from 3.8% - 5.32% between tests. The values of SEMs were ranging from 1.24 to 1.93. This is helpful for the use of outcome measures during rehabilitation as it gives clinicians and patients an idea as to when a rehabilitation protocol is meeting its aims. For the comparison among individuals normalized scores of reach distances are important, however for one individual, absolute scores are more useful and appropriate.

In the present study the ICC values of both normalized and absolute data in anterior reach were maximum which is in agreement with previous studies.[1,2] Feedback mechanism could be a possible explanation for maximum ICC value in anterior reach direction. It is explained that, under normal conditions, the somatosensory and visual subsystems are the main mediators of balance and postural awareness.[30] In the anterior reach direction, subjects receive visual feedback from the swing limb as they move and can spot the scored reach distance on each trial. In the remaining directions, visual awareness is decreased, resulting in more variations in readings of reach distances.

In this study results were calculated from the data taken from sedentary collegiate students, hence, potentially not limiting the generalization of our findings to trained and active persons only. Certain limitations to this study do exist. First, only the data of the dominant limb was analysed for each subjects and secondly, all testing was recorded by one observer only. Thus, further studies are required to assess the interrater test-retest

reliability of the YBT in present population and compared the results of both the lower limbs.

CONCLUSIONS

Y Balance Test is an excellent reliable tool to assess dynamic balance with the standardized device and protocol and hence a useful aid for musculoskeletal and other clinical problems.

By determining the reliability of this test with minimal levels of error scores, clinicians can better detect asymmetries in participant's performance. It will also contribute in the decision-making process for return to advanced activity phase. Now both normalised and absolute score references are available which will help the scholars and professionals to evaluate the actual improvements after rehabilitation and training program. These will be helpful in understanding if improvements are because of measurement error.

REFERENCES

1. Shaffer SW, Teyhen DS, Lorenson CL, Warren RL, Koreerat CM, Straseske CA, Childs JD. Y-balance test: a reliability study involving multiple raters. Mil Med. 2013;178(11):1264-70. doi: 10.7205/MILMED-D-13-00222.
2. Plisky PJ, Gorman PP, Butler RJ, Kiesel KB, Underwood FB, Elkins B. The reliability of an instrumented device for measuring components of the star excursion balance test. N Am J Sports Phys Ther. 2009;4(2):92-99.
3. Winter DA, Patla AE, Frank JS. Assessment of balance control in humans. Med Prog Technol. 1990;16(1-2):31-51.
4. Kinzey SJ, Armstrong CW. The reliability of the star-excursion test in assessing dynamic balance. J Orthop Sports Phys Ther. 1998;27(5):356-60. doi: 10.2519/jospt.1998.27.5.356.
5. Nashner LM, Shumway-Cook A, Marin O. Stance posture control in select groups of children with cerebral palsy: deficits in sensory organization and muscular coordination. Exp Brain Res. 1983;49(3):393-409. doi: 10.1007/BF00238781.
6. Aminaka N, Gribble PA. Patellar taping, patellofemoral pain syndrome, lower extremity kinematics, and dynamic postural control. J Athl Train. 2008;43(1):21-28. doi:10.4085/1062-6050-43.1.21
7. Akbari M, Karimi H, Farahini H, Faghihzadeh S. Balance problems after unilateral lateral ankle sprains. J Rehabil Res Dev. 2006;43(7):819-24. doi: 10.1682/jrrd.2006.01.0001.
8. Gribble PA, Hertel J, Denegar CR, Buckley WE. The Effects of Fatigue and Chronic Ankle Instability on Dynamic Postural Control. J Athl Train. 2004;39(4):321-329.
9. Gribble PA, Hertel J, Denegar CR. Chronic ankle instability and fatigue create proximal joint alterations during performance of the Star Excursion Balance Test. Int J Sports Med. 2007;28(3):236-42. doi: 10.1055/s-2006-924289.
10. Herrington L, Hatcher J, Hatcher A, McNicholas M. A comparison of Star Excursion Balance Test reach distances between ACL deficient patients and asymptomatic controls. Knee. 2009;16(2):149-52. doi: 10.1016/j.knee.2008.10.004.
11. Plisky PJ, Rauh MJ, Kaminski TW, Underwood FB. Star Excursion Balance Test as a predictor of lower extremity injury in high school basketball players. J Orthop Sports Phys Ther. 2006;36(12):911-9. doi: 10.2519/jospt.2006.2244.
12. Olmsted LC, Carcia CR, Hertel J, Shultz SJ. Efficacy of the Star Excursion Balance Tests in Detecting Reach Deficits in Subjects With Chronic Ankle Instability. J Athl Train. 2002;37(4):501-506.
13. Sefton JM, Hicks-Little CA, Hubbard TJ, Clemens MG, Yengo CM, Koceja DM, Cordova ML. Sensorimotor function as a predictor of chronic ankle instability. Clin Biomech (Bristol, Avon). 2009;24(5):451-8. doi: 10.1016/j.clinbiomech.2009.03.003.
14. Filipa A, Byrnes R, Paterno MV, Myer GD, Hewett TE. Neuromuscular training improves performance on the star excursion balance test in young female athletes. J Orthop Sports Phys Ther. 2010;40(9):551-8. doi: 10.2519/jospt.2010.3325.

15. Hale SA, Hertel J, Olmsted-Kramer LC. The effect of a 4-week comprehensive rehabilitation program on postural control and lower extremity function in individuals with chronic ankle instability. J Orthop Sports Phys Ther. 2007;37(6):303-11. doi: 10.2519/jospt.2007.2322.
16. Gribble PA, Kelly SE, Refshauge KM, Hiller CE. Interrater reliability of the star excursion balance test. J Athl Train. 2013;48(5):621-626. doi:10.4085/1062-6050-48.3.03
17. Gribble PA, Tucker WS, White PA. Time-of-day influences on static and dynamic postural control. J Athl Train. 2007;42(1):35-41.
18. Hertel J, Braham RA, Hale SA, Olmsted-Kramer LC. Simplifying the star excursion balance test: analyses of subjects with and without chronic ankle instability. J Orthop Sports Phys Ther. 2006;36(3):131-7. doi: 10.2519/jospt.2006.36.3.131.
19. Bressel E, Yonker JC, Kras J, Heath EM. Comparison of static and dynamic balance in female collegiate soccer, basketball, and gymnastics athletes. J Athl Train. 2007;42(1):42-46.
20. Sawkins K, Refshauge K, Kilbreath S, Raymond J. The placebo effect of ankle taping in ankle instability. Med Sci Sports Exerc. 2007;39(5):781-7. doi: 10.1249/MSS.0b013e3180337371.
21. Alam F, Raza S, Moiz JA, Bhati P, Anwer S, Alghadir A. Effects of selective strengthening of tibialis posterior and stretching of iliopsoas on navicular drop, dynamic balance, and lower limb muscle activity in pronated feet: A randomized clinical trial. Phys Sportsmed. 2019;47(3):301-311. doi: 10.1080/00913847.2018.1553466.
22. López-Valenciano A, Ayala F, De Ste Croix M, Barbado D, Vera-Garcia FJ. Different neuromuscular parameters influence dynamic balance in male and female football players. Knee Surg Sports Traumatol Arthrosc. 2019;27(3):962-970. doi: 10.1007/s00167-018-5088-y.
23. Bagherian S, Ghasempoor K, Rahnama N, Wikstrom EA. The Effect of Core Stability Training on Functional Movement Patterns in College Athletes. J Sport Rehabil. 2019;28(5):444-449. doi: 10.1123/jsr.2017-0107.
24. Kinzey SJ, Armstrong CW. The reliability of the star-excursion test in assessing dynamic balance. J Orthop Sports Phys Ther. 1998;27(5):356-60. doi: 10.2519/jospt.1998.27.5.356.
25. Coppieters M, Stappaerts K, Janssens K, Jull G. Reliability of detecting 'onset of pain' and 'submaximal pain' during neural provocation testing of the upper quadrant. Physiother Res Int. 2002;7(3):146-56. doi: 10.1002/pri.251.
26. Kropmans TJ, Dijkstra PU, Stegenga B, Stewart R, de Bont LG. Smallest detectable difference in outcome variables related to painful restriction of the temporomandibular joint. J Dent Res. 1999;78(3):784-9. doi: 10.1177/00220345990780031101.
27. Lanning CL, Uhl TL, Ingram CL, Mattacola CG, English T, Newsom S. Baseline values of trunk endurance and hip strength in collegiate athletes. J Athl Train. 2006;41(4):427-434.
28. Munro AG, Herrington LC. Between-session reliability of the star excursion balance test. Phys Ther Sport. 2010;11(4):128-32. doi: 10.1016/j.ptsp.2010.07.002.
29. Gribble PA, Hertel J, Plisky P. Using the Star Excursion Balance Test to assess dynamic postural-control deficits and outcomes in lower extremity injury: a literature and systematic review. J Athl Train. 2012;47(3):339-57. doi: 10.4085/1062-6050-47.3.08.
30. Riemann BL, Lephart SM. The Sensorimotor System, Part II: The Role of Proprioception in Motor Control and Functional Joint Stability. J Athl Train. 2002;37(1):80-84.

Source of Support: Nil, Conflict of Interest: None declared