ABSOLUTE VARIABILITY AND RELATIVE RELIABILITY OF THE TIMED STANDING BALANCE TEST IN CHILDREN WITH DOWN SYNDROME[1, 2]

Vencita Priyanka Aranha, Rina Panicker**, Asir John Samuel****

Corresponding Author: Professor, Maharishi Markandeswar. E-mail: asirjohnsamuel@mmumullana.org

* Post Graduate student, Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation, Maharishi Markandeshwar University, Mullana-133207. Haryana. India

** Lecturer, Alva's college of Physiotherapy, Moodabiri-574227. Karnataka, India.

*** Assistant Professor, Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation, Maharishi Markandeshwar University, Mullana-133207. Haryana. India

Abstract

Background: Reliability of an instrument or clinical test should be known in the field of rehabilitation medicine. But the reliability of most of clinical test to be used among pediatric population with disabilities is yet to be known. One among them is the timed standing balance test. Aim: To determine the minimal detectable change at 95% confidence (MDC95) for the static and dynamic standing balance test in children with Down syndrome (DS). Methods: A sample of nine (09) children with DS, aged between 8 and 17 years were recruited randomly from the recognized special school. Children with DS who were able to understand and obey simple commands were selected and noted their anthropometric measurements. Standing balance was assessed using timed unipedal stance on a hard floor for static and on foam with uniform density for dynamic balance. Standing balance was assessed thrice with an interval of minimum two (02) days in four conditions, Eyes Open Static (EOS), Eyes Closed Static (ECS), Eyes Open Dynamic (EOD) and Eyes Closed Dynamic (ECD) to estimate test retest reliability, Intraclass correlation coefficient (ICC). Then standard error of measure (SEM) and minimal detectable change (MDC95) was calculated. Results: Test retest reliability in four conditions, EOS, ECS, EOD and ECD are ICC = 0.93, 0.91, 0.92 and 0.91 respectively while 1.27 s, 1.63 s, 0.58 s and 0.61 s are the MDC95 required in four conditions. Conclusion: Absolute variability and relative reliability of the timed standing balance test in children with DS have been established.

Keywords: Adolescent; Balance; Down syndrome; Reliability; Static balance; Test-retest.

1 The foam pad used in the study was sponsored by Mrs. Gracy Lobo and Mr. Lancy Lobo, Almana General Hospital, Saudi Arabia and transport facility to reach the special school was provided by Mr. Valerian Clement Aranha, Vencita Villa, Nakre, Karkala, India.

2 The extension of this study is published in, Aranha VP, Samuel AJ, Saxena S. Reliability and sensitivity to change of the timed standing balance test in children with down syndrome. J Neurosci Rural Pract (2015), http://dx.doi.org/10.4103/0976-3147.165412 (in press)

• Artigo submetido para avaliação em 06/07/2015 e aceito para publicação em 31/07/2015 •

DOI: http://dx.doi.org/10.17267/2238-2704rpf.v5i2.642

INTRODUCTION

An instrument or test which is free of measurement error is needed in the field of rehabilitation medicine and physical therapy to document the actual improvement in patient ability. Reliability measurements denote to what extend the clinical test scores fall outside the measurement error.[1] Reliability of an instrument or test depends on their relative reliability and absolute variation. Consistency of clinical test scores refers to the relative reliability and measured with correlation coefficients.[2] Absolute variation indicates the variability of test scores with repeated measurements, represented by the Minimal Detectable Change (MDC) scores.[3] To date, as far as to our knowledge, there is no published literature describing the reliability measures among children with disabilities.

Down syndrome belongs to the group of chronic encephalopathy, congenital disease, due to the result of malformation linked to genetic factors. Children with DS have specific problems in motor development such as lack of balance, eye-hand coordination, dexterity and increased reaction time.[4] This might be due to poor myelination of the descending cerebral and brain-stem neurons and a reduction in both the number and connections of neurons in the higher nervous centers, such as motor cortex, basal ganglia, cerebellum, and brain stem.[5]

The deficit in postural control in DS is often associated with problems in motor coordination and sensory-motor integration. This makes them less capable of making anticipatory postural adjustments.[6] Hence, accurate measurement of standing balance is essential in assessing the effectiveness of the balance training.

There are many techniques that have been used to measure balance but most of the laboratory measuring equipment's are costly, highly technical and not portable.[6] Moreover, it is very difficult to apply it on children with Down syndrome. In special school based setting, the laboratory equipment being cumbersome in measuring balance with functional practical difficulty. Static and dynamic timed standing balance test being simple in instrumentation uses no sophisticated mechanism for measuring balance.[7] But how much is reliable in measuring balance among the children with DS, is not yet established. To establish the reliability of an instrument, both relative reliability and absolute variation should be determined. Intra class correlation coefficient (ICC) is one of the method to establish the relative reliability and minimal detectable change (MDC) for measuring the absolute variation. Therefore, we determine the test-retest reliability and minimal detectable change (MDC) of data obtained with a static and dynamic balance test in adolescent with DS.

PROCEDURE

This was a prospective study done on children with DS from Chetana special school, karkala, India between March, 2013 to June, 2013. The study was approved from the review board on ethics for research and the study protocol has been registered in trials Registry (CTRI/2013/06/003724). A prior informed consent was obtained from the school authorities as well as from all the participants' parents/guardians. The nature and purpose, procedures, risks and benefits of the study was explained to them while taking due care to avoid any bias. They were ensured that confidentiality of the data would be maintained. The study was done according to guidelines for biomedical research on human participants, laid by Indian council for medical research (ICMR) on 2008.

The study was designed to recruit nine subjects to have 80% power with an expected reliability (ρ_o) of >0.6 and an expected width of 0.2 at p=0.05 level for three measurements.[9,10] The sample was recruited by the convenience sampling technique for the cross-sectional study. Children with DS who were able to understand and follow simple command and able to stand independently without any supportive devices were designed as their inclusion criteria. Nine (09) children were included as they met with the inclusion criteria, among them were, 6 boys and 3 girls aged between 9-17 years. Every child was instructed and shown how the test had to be performed. A digital stop watch was used to measure the time. The test was conducted bare foot to maintain uniformity. All the anthropometric measures were taken in the beginning of the study.

The static balance was tested by standing on a floor and dynamic balance by standing on a foam pad (50×48×8cms, 0.8 kilograms). The test was conducted with four different protocols (eyes open static = EOS, eyes closed static = ECS, eyes-open dynamic = EOD, and eyes closed dynamic= ECD) and the order of each protocol was randomized by lottery method.

The assessment was done on two surfaces, flat normal floor for static and foam pad for dynamic surface.

STATIC BALANCE

Subjects were asked to place their hands on their hip and they were asked to focus on a target which was placed at the eye level. They were then asked to stand on their right foot and raise the opposite foot from the floor (90° knee flexion) as in Figure 1. The electronic stopwatch was started as soon as the subject raised the foot from the floor and was stopped on loss of balance. Loss of balance included removal of one hand from the hip, touching the floor with the non–weight-bearing foot and movement of the weight-bearing foot from its original position on the floor. The video illustrating the procedure for static surface can be viewed from http://youtu.be/Aqf7ox8Q6m4

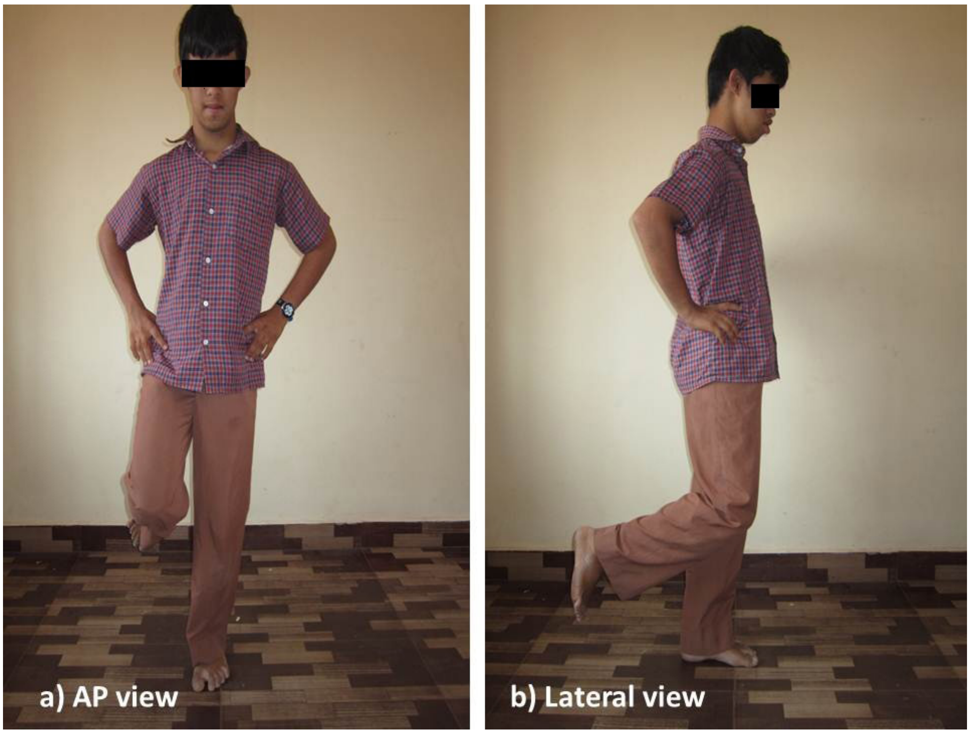

Figure 1 - A child with Down syndrome (DS) performing the timed static standing balance test by standing over the flat surface

Note: Figure 1 has appeared in a previous publication in, Aranha VP, Samuel AJ, Saxena S. Reliability and sensitivity to change of the timed standing balance test in children with down syndrome. J Neurosci Rural Pract (2015), http://dx.doi.org/10.4103/0976-3147.165412. (in press)"

The same procedure was repeated for the trial with closed eyes (ECS) in which eyes were closed before the raising of leg. The stopwatch was stopped on opening of eye and loss of balance.

DYNAMIC BALANCE

The same procedure was again repeated on a foam surface (Figure 2) with eye open and eye closed. Here the stopwatch was started as above but was stopped on loss of balance and on movement of the foam from its original position. The above procedure for estimating dynamic balance can be viewed from the video http://youtu.be/ydxJBfaKZeY

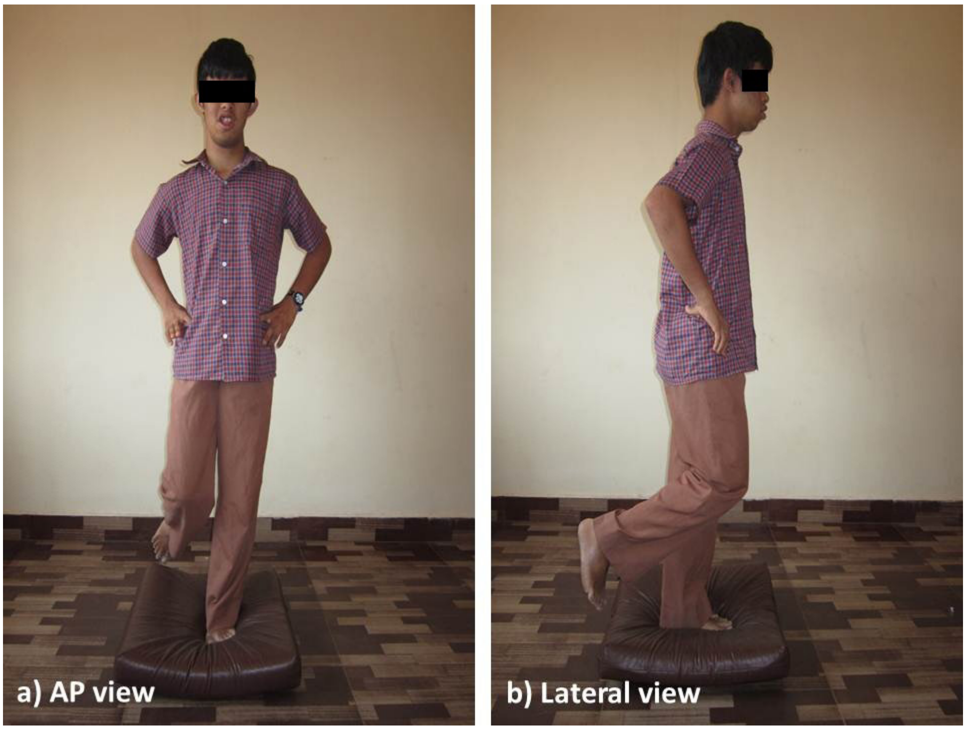

Figure 2 - A child with Down syndrome (DS) performing the timed dynamic standing balance test by standing over the foam surface

Note: Figure 2 has appeared in a previous publication in, Aranha VP, Samuel AJ, Saxena S. Reliability and sensitivity to change of the timed standing balance test in children with down syndrome. J Neurosci Rural Pract (2015), http://dx.doi.org/10.4103/0976-3147.165412. (in press)"

Due to small sample size, the assessment were made on three occasions, by the same examiner with two days interval between each session.

DATA ANALYSIS

Data analysis was performed using the statistical package for social science, IBM®SPSS®v20 (IBM USA). Normality of collected data was established by Shapiro-Wilk test. Hence, the data does not follow normal distribution, descriptive statistics were expressed in median (range) and non-parametric tests are used to analyse. The test score data was transformed logarithmically and then back transformed to report the geometric mean and 95% Confidence Interval (CI). When data are skewed geometric mean and 95% CI are appropriate than to express the arithmetic mean and Standard Deviation (SD). Thus central tendency of standing balance test were analysed. The reliability of the assessment instrument was evaluated by estimating its relative reliability and measurement of absolute variation.

To analyse the relative reliability intra-class correlation coefficient ($ICC_{1,k}$) [k=3] was used. We defined ICC values from 0.75- 0.89 representing good reliability and 0.90-0.99 representing excellent reliability.[10] Standard error measurement (SEM) [1] and MDC were used to estimate the measure of absolute variation. They were calculated using the formulae, SEM = SD x √ (1-reliability) and MDC_{95} = $\sqrt{2}$ (1.9) (SEM).[3,11] Significant level was set to p less than 0.05 ($p < 0.05$) to minimize the type-II error.

RESULTS

Total of nine (09) children with DS recruited for the study, six (06) were boys and three (03) were girls. Though unequal representation exists between the gender, there is no significance difference ($p<0.05$) exists between the mean demographic parameters, are clear from Table 1. Table 2 shows the geometric mean with 95% confidence interval (CI) and median with range test scores of timed standing balance test in four (04) different conditions. EOS condition has high test score while least being the ECD condition. ECS and EOD are with similar test scores. Thus balance is more compromised in ECD condition, as they are able to maintain unipedal stance less than couple of minutes (Table 2) in timed standing balance test. Relative reliability and absolute variability of the standing balance test in terms of ICC and MDC_{95} are displayed in Table 3. ICC value ranges between 0.91 and 0.93 in all four (04) test condition while variability of standing balance test scores range from 0.58 to 1.63 seconds.

Table 1 - Demographic characteristics of the children with DS

Characteristics	Boys * (N=6)	Girls * (N=3)	p-value
Age (yrs)	14 (8-17)	13 (9-15)	0.36
Height (cm)	148.3 (131-158)	142 (137-144)	0.36
Weight (kg)	44.1 (28.9-67.5)	32.5 (32.1-36.6)	0.21
BMI	19.9 (16.5-28.1)	17.1 (15.7-18.2)	0.19
WHR	0.87 (0.81-0.92)	0.88 (0.86-90)	0.92

Note: * - expressed as Median (range)

Abbreviations: DS – Down syndrome; BMI – Body Mass Index; WHR - Waist Hip Ratio..

Table 2 - Standing static and dynamic balance test's mean and median scores in children with DS

Balance test	Geometric Mean (95% CI) in (s)	Median (Range) in (s)
EOS	4.21 (2.08 – 5.63)	6.4 (1.2 – 28.9)
ECS	2.68 (1.59 – 4.57)	2.15 (1.3 – 9.4)
EOD	2.67 (1.55 – 5.33)	2.25 (1.2 – 10.7)
ECD	1.57 (1.05 – 3.09)	1.6 (0.7 – 4.6)

Abbreviations: DS – Down syndrome; EOS **-** eyes open static; ECS **-** eyes closed static; EOD - eyes-open dynamic; ECD - eyes closed dynamic; CI – confidence Interval.

Table 3 - Test-retest reliability, SEM and MDC95 of static and dynamic standing balance tests

Balance Test	ICC	SEM (s)	MDC_{95} (s)
EOS	0.93	0.46	1.27
ECS	0.91	0.59	1.63
EOD	0.92	0.21	0.58
ECD	0.91	0.22	0.61

Abbreviations: EOS - eyes open static; ECS - eyes closed static; EOD - eyes-open dynamic; ECD - eyes closed dynamic; ICC - intra-class correlation coefficient; SEM – standard error of measurement; MDC_{95} – minimal detectable change with 95% confidence interval.

DISCUSSION

The study is done with an aim to establish the reliability of static and dynamic balance in the children with DS. It was a cross sectional study which included 9 children with DS who met with the inclusion criteria. The static balance was measured by standing on a single limb on a firm floor and dynamic balance by single limb standing on a foam surface (50×48×7cm 0.8kg). The foam pad was used as it is easily available, easy to clean, easy to transport and easy to use for a child with DS when comparing with other balance measuring instruments such as balance master.

The result of this study shows that there is no significant difference between the gender, in their height and weight. But we have unequal gender representation, comprising only 33.3% (03) boys to 66.7% (06) girls. This was supported by Ebrahim e outros[12] who discovered no significant difference in static and dynamic balance between the genders (school aged children) and even in the studies done by Peeters e outros[13] and Ekdahl e outros[14]

The median of maximum time taken by the children in this study is 6.4 seconds and geometric mean is 4.21 seconds which is relatively small when compare with the maximum time of 180 seconds reached by healthy athletes of 14-24 years. Mean time of 44 seconds in people 20 to 29 years of age was established by Eldahl e outros.[14] Bohannon e outros[15] demonstrated the maximum time of 30 seconds in subjects between 20 and 29 years. As the above studies were reported from healthy human subjects and the use of arithmetic mean which is inappropriate in skewed data might have led to the differences. As none of the children reached maximum, the timed standing balance test can be well suited for children with DS. They have no possible ceiling effects among them. Based on geometric means, reported balance ability in eyes-open conditions exceeds that of eye-closed conditions.

Hammarén e outros[16] found the test-retest reliability of standing balance is high which lies between ICC = 0.87 and 0.98 among individuals with congenital myotonic dystrophy type 1 aged 20-60 years, where as in this study ICC value for standing balance test varies between 0.91-0.93 (table 3). This according to Shrout and Fleiss criteria has excellent reliability.[10] Moderate reliability were established in children aged, 4 to 6 years, (ICC=0.59–0.77) and among adults following stroke, (ICC=0.44–0.75) by Bohannon e outros[15] These differences might have attributed due to difference in their age and disease variability. Riemann e outros[17] demonstrated excellent reliability of dynamic standing balance test among adolescent without neurological impairments. But in our preliminary study, we obtained ICC value ranged from 0.85 to 0.96 for the entire static and dynamic standing balance test.[18] In the study, both static and dynamic standing balance test to have excellent reliability. This demonstrates that standing balance test to be more reliable among individuals with relatively low balance ability than with improved balance.

To what extent the clinical test is free from measurement error indicates the reliability. But caution should be required while interpreting reliability based on ICC alone. Hence, we considered both SEM and MDC of the standing balance test. MDC is the minimal amount of change score outside the measurement error that reflect the true change which is not due to chance variation. It is the amount of change score that need to exceed test-retest reliability and above the threshold of error. MDC can be generated statistically from reliability scores easily. MDC is not same as the minimal clinical important difference (MCID). We did not calculate the MCID; henceforth we are unclear that how much change of standing balance test score is considered clinically meaningful.

The major strength of our study is randomizing the order of executing four test conditions. By this ascending increasing difficulty in timed test was eliminated and only balancing ability in the four different conditions were established. The next is estimating geometric mean of the timed balance test instead of arithmetic mean which was inappropriate in case of data that does not follow the normal Gaussian distribution. The timed standing balance in children with DS has no ceiling effect. The limitation of this study is that the study participation may represent the children with DS in special school. This may be a risk for the external validity.

Further research can be done on different pediatric population with disabilities and also to validate timed standing balance test among them. We also advocate the use of advanced sensor in replacement of electronic stopwatch and to estimate MCID of the timed standing balance test among the children with DS. The physical therapist or any rehabilitation professionals, with the knowledge of these MDC values can be 95% confident that the true change in test scores has occurred or not. Thus evidence based quality focused clinical decisions can be made on rehabilitation.

CONCLUSION

The study proved that the entire timed standing balance test to have excellent reliability among the children with DS. Relative reliability and absolute variation of the timed standing balance test has been established. how the test had to be performed. A digital stop watch was used to measure the time. The test was conducted bare foot to maintain uniformity. All the anthropometric measures were taken in the beginning of the study.

REFERENCES

1. Domholdt E. Rehabilitation Research: Principles and Applications. 3rd ed. St Louis, MO: Elsevier Saunders; 2005.
2. Portney LG, Watkins MP. Foundations of Clinical Research: Applications to Practice. 2nd ed. Upper Saddle River, NJ: Prentice Hall Health; 2000.
3. Haley SM, Fragala-Pinkham MA. Interpreting change scores of tests and measures used in physical therapy. Phys Ther. 2006;86:735–743.
4. Carvalho RL, Vasconcelos DA. Motor behavior in Down Syndrome: Atypical Sensoriomotor Control. In: Dey S. Prenatal diagnosis and screening for Down syndrome. INTECH Rijeka, Croatia 2001. Chapter 3, p. 33-39.
5. Malak R, Kotwicka M, Krawczyk-Wasielewska A, Mojs E, Samborski W. Motor skills, cognitive development and balance functions of children with Down syndrome. Ann Agric Environ Med. 2013;20:803-6.
6. Villarroya MA, Gonzále-Agüero A, Moros-Garcia T, de la Flor Marin M, Moreno LA, Casajús JA. Static standing balance in adolescents with down syndrome. Res Dev Disabil. 2012;33:1294-300.
7. Emery CA, Cassidy JD, Klassen TP, Rosychuk RJ, Rowe BB. Development of a clinical static and dynamic standing balance measurement tool appropriate for use in adolescents. Phys Ther. 2005;85(6):502-14.
8. Donner A ,Eliasziw M. Sample size requirements for reliability studies. Stat Med. 1987; 6:441-8.
9. Shieh G. Sample size requirements for the design of reliability studies: precision consideration. Behav Res Methods. 2014;46:808-22.

10. Shrout PE, Fleiss JL. Intra-class correlations: uses in assessing rater reliability. Psychol Bull. 1979; 86:420–28.

11. Stratford PW. Getting more from the literature: estimating the standard error of measurement from reliability studies. Physiother Can. 2004;56:27-30.

12. Ebrahim AH, Al-Kahky A. Comparative Study of Static and Dynamic Balance of School Age Children with and Without Backpack. Bull. Fac. Ph. Th. Cairo Univ. 2006;2(2).

13. Peeters H, Breslau E, Mol J, Caberg H. Analysis of posturographic measurements on children. Med Biol Eng Comput. 1984;22(4):317-21.

14. Ekdahl C, Jarnlo GB, Andersson SI. Standing balance in healthy subjects. Evaluation of a quantitative test battery on a force platform. Scand J Rehabil Med. 1989;21(4):187-95.

15. Bohannon RW, Larkin PA, Cook AC, Gear J, Singer J. Decrease in timed balance test scores with aging. Phys Ther. 1984;64(7):1067-70.

16. Hammarén E, Ohlsson JA, Lindberg C, Kjellby-Wendt G. Reliability of static and dynamic balance tests in subjects with myotonic dystrophy type 1: Advances in Physiotherapy. 2012;14: 48–54.

17. Riemann BL, Guskiewicz KM, Shields EW. Relationship between clinical and forceplate measures of postural stability. The Journal of Sport and Rehabilitation. 1999;8:71-82.

18. Aranha VP, Paniker R, Samuel AJ. Intra-Observer reliability of static and dynamic standing balance test in the children with Down's syndrome. In: J Alagesan, S Subramanian, A Ramadass, V Mohan, editors. Int J Pharm Bio Sci. Stride 2013: Proceedings of the International Conference on Physiotherapy; 2013 Oct 18-19; Chennai, India; 2013.p. 55.