Original Article

Normative Values of Balance Tests in Neurological Assessment of Sports Related Concussions

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Objectives: Deterioration in postural control mechanisms is termed postural instability and results increased postural sway and many laboratory techniques and instruments are characterized by a wide range of neurological signs and symptoms to the medical management. Thus the current study designed to assess the reliability of commonly used clinical measures of balance and determined normal values. Also, the second purpose was to evaluate the scrutiny of age, length; weight and body mass index (BMI) effects on performing clinical balance tests.

Method: One hundred and thirty three participants (18-59 years), that have at least three time sports activity in one week, performed three timed tests including Time-up and Go (TUG), Tandem Gait (TG), and Walking on Balance Beam (WOBB) on firm surface.

Results: Reliability data were produced for each tests of motor performance. We found that the first performance of three trials was slower, and the relationship between some factors and these battery tests were examined. Means (± SD) for each measure were averaged across three trials. Time to complete TG was 13.6 ± 1.1s. TUG value was 6.9 ± 1.03 and WOBB was 6.9 ± 1.03s. Conclusions: our results revealed that three clinical balance test batteries - TUG, TG and WOBB tests are the stability measures to assess the sports related concussion. Also, the results of current study showed that the time to perform these tests was slower than the other studies.

Keywords: Normative value, Gait, Reliability, Sports related concussions

Introduction

Decadence in postural control mechanisms is termed postural instability and results increased postural sway (1). Stabilitization of the whole body orientation respecting the gravity, the support surface, visual field, muscles and central nervous system is a critical portion of postural control (2-5). Motor co-ordination (6) and standing balance (3) are essential for many activities of daily living and adequate upper extremity performance. The ability to walk is a rapid and inexpensive measure of physical function and an important component of quality of life (7).

Many laboratory techniques that including sports concussion as a common injury in sport (8-10) are characterized by a wide range of neurological signs and symptoms and especially in mild traumatic concussion (11-13). Variety of clinical instruments and symptom checklists used to assess for a sport concussion with return-to-play decisions to the medical management (14, 15). Several standardized assessment (*i.e.* standard assessment of concussion (SAC)) or computerized test batteries are commonly used as a measure of impaired cognitive performance after injury. The computer administered test batteries designed for concussion management and return-to-play decisions in athletics are COG sport and immediate post-concussion assessment and cognitive testing (IMPACT). These tasks are described as measuring psycho-motor speed and offered to administration and scoring of test protocols. But these tests have not yet been validated for use in the follow up of sports related concussion (10, 16-18). Recently by combination of some validated tools into a single sideline, the sport concussion assessment tool (SCAT) was developed

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through the first and second International Symposiums, held in Vienna, Austria and Prague respectively. This document is developed for health professionals, coaches and other people involved in the care of injured athlete (17). Shuttelworth (2008) proposed that neuro-cognitive evaluation is warranted for any concussive injury to increase diagnostic sensitivity and provide prognostic indications (18).

Some clinical measurement tools have been developed in an attempt to measure dynamic and static balance. These tools were developed to assess balance during a functional performance task in normal participants. Whereas these tests are commonly used as evaluation of neuro-motor function, they have the potential to act as valuable screening items in the assessment of sports related concussions (18). Quantitative gait analysis has been used to illustrate of neurological characteristic features of gait disturbances (19). Many studies have compared gait parameters in wide variety of diseases with impaired gait and also in healthy elderly individuals (19–24). Making disequilibrium in patients with few or any neurological signs accounted for gait disturbances (22), and some studies have examined the chronic effects of concussion on gait (25). Thus assessment these screening tools are necessary for a sport concussion. In this study, these evaluation tools were Time up and GO (TUG) test (26), Tandem Gait (TG) test and Walking on Balance Beam (WOBB). The last test was new and examined in our study.

Schneiders *et al* (2010) determined normative values for TG test and demonstrated that TG had excellent reliability in the neurological assessment of sport concussions. Time to complete this test was 11.2 ± 1.2 s in healthy subjects of 16-37 years old (27). In another study the reliability coefficients for TG were examined and suggested that further study should be directed toward improving the validity of this test for use with older people (28). In Bischoff *et al* investigation, it is recorded that 92% of community-dwelling elderly performed the TUG test in less than 12 second. They recommended the TUG test as a screening tool and noted that it is a necessary tool assessment in elderly women (29). Isles *et al*, stated that normal values for TUG test in subjects of 20-29 and 30-39 years old were 5.31 ± 0.25, and 5.39 ± 0.23, respectively (30).

Therefore, the purpose of this study was to screen the three timed tests of motor performance for used in evaluation of sports concussion and to verify normative values for these tests. The second purpose of this study was to determine the influence of age, sex, leg dominance and body mass index.

Materials and Methods

Convenience samples of persons aged 18-59 years were recruited for the study and one hundred thirty three participants, 50 women (X=22.1 ± 1.97) and 83 men (X=27.9 ± 9.45) were finally enrolled. As Schneider's (2010) refer, according to methods used in Povlov *et al* (2010) and linnet (2000) studies, 120 participants were the enough sample size for calculation of 90% confidence interval and 95% central interval in parametric and non-parametric researches (cited by Schneiders *et al*., 2010) (27, 31, 32). The subjects were chosen from Shahid Chamran University of Ahvaz that had at least three athletic activity sessions in every week. After giving their written informed consent, subjects participated in a structured interview and filled questionnaire and the persons with identified muscle skeletal or neurological disorder, use of drugs that might affect motor tasks and diabetes mellitus were screened from the study. The order effects were randomly identified. Thirty-six percent of subjects performed TUG test, and 33% executed TG test at first and another one did WOBB test early. Tests performed without shoes and were given rests between repetitions of tests almost 10 seconds and between tests 15 seconds, so that fatigue was not a problem. Also between the second repetitions of the tests in the same day, gave 15 minute rests. In beginning the tests, the subjects were given one untimed trait to insure they understood the tests and then performed three timed trails.

Measurements

The assessment procedure started with measured variables such as height, weight and BMI in the sport medicine clinic of the University. The clinical balance tests used were the TUG test, the TG test and WOBB test that were performed using the protocols described by the original authors excepted of the WOBB test.

The TUG test begins with the subject sitting correctly in a chair and his/her back should resting on the back of the chair, a piece of tape or other marker is placed on the floor 3 meters away from the chair, then he/she will be asked to do this instructions: " on the word GO you will stand up, walk to the line on the floor, turn around and walk back to the chair and sit down.

Please, walk at your regular pace". Test score is the timing that starts on the word " GO" and stops when he/she is seated again correctly in the chair (26).

TG test is preformed the same as the time-up-and go test except that the test starts seating in a chair, then standing with foot together behind a starting line with eyes open, and then the subject walks along a 3 m line in an alternate heel-to-toe fashion, turns and returns to the start point and the time of the correct performance is measured.

WOBB test was the new test that examined in the study and used to developed balance and co-ordination. The subjects began the task standing with their feet together behind the Balance Beam and then with preferential foot. Subjects walked along a 5 cm wide, 2.48 m line with short steps and while their hands were free. Subjects failed the test if they got deviated from the track. Three trials were recorded.

Data analysis

The testing protocol was performed by two trained and harmonic examiners–examiner 1 and examiner 2. Intra–rater reliability of the motor performance measures are based on the same examiner – examiner 1 – during the same test session and 1 week following the start testing and inter-rater reliability was assessed by the two examiners both during one performance, simultaneously. We used t-tests and general linear model to investigate the influence of several factors -leg dominance, hand dominance, order of testing, age, sex and body max index. The levels of significances were considered at $P < 0.05$ and $P < 0.01$.

Results

One hundred and thirty three subjects aged 18-39 years, with such demographics (50 women, 83 men, weigh: 63.84 ± 10.25, height: 168.21 ± 5.5, BMI: 22.55 ± 3.53) participated in the current study. The intra- rater and inter-rater reliability results are summarized in table 1. The results revealed absolute reliability for TG and TUG and WOBB tests suggesting that they could be clinically possible outcome index of balance and co-ordination. Also, there were a significant difference ($P < 0.001$) between first trial compared to second and third trials in the three tests. Also, there were an apparent age and length influences in TG. For Gait Equilibrium test just determined age effect. About TUG also the results shown the significant age, weight and BMI effects were associated with the time to perform TUG. This study noted no order effect for any motor performance measure.

Discussion

In this study TG, WOBB, and TUG proved to be reliable tests and can be used for neurological screening of sports-related concussion. Using similar protocol, Schneiders *et al*. (2010) reported that the TG was precise and reliable test when administered by the same evaluator. Also, this study supported the results of Schneiders et al (2010) study findings, that the first trial was considerably slower than subsequent trials. But the current study reports values slower for motor performance measured especially in TG. Participants' wide age range and different individul indices including sex, age, height, weight, and body mass in the two studies might be the cause of these different results.

Normative Values of Balance Tests

In The TUG test performance of subjects independent on effects of organ impairments, such as low muscle strength and decreased balance (29) then these tests have enough reliability in different environments. This clinical measure assess is useful in screening, transition phases associated with balance, such as stand, turn, and sit, as well as gait and the sensory-motor abilities are combined in the test and can be easily examined (33). Also apparently there is no report about reliability of WOBB in the previous investigations and this study is the first to report normative values for timed versions of this tool.

Unimportant differences were found between sexes in these tests. Because of significant effect of age in studies (34), it was considered important to utilize different ages in test performance batteries and should be applied in sport concussion assessments. Additionally, in clinical evaluation techniques, repeated trials (35) and learning effects (36) are important aspects, too.

Though sport can play a key role in the lives of people, injury incidence is common in sport locations. Unfortunately, there are not injury reports in our country -Iran- especially in mild injuries. In one investigation in Taekwondo, as the most popular martial art among Iranian sportsmen, the most frequent injuries were mild (68.8%) and sustained or moderate injuries (24.7%) and a small minority was as critical injuries (37). Our study is the first tests reliability research in concussion in Iran, and further investigation is necessary to evaluate these motor performance measures to other health subjects and functional status parameters.

A limitation of our study was the small sample size and left hand and left food which were of the study. In order to improve the results, further studies with wide and different type subjects is recommended. Another limitation of this study was the in inter-rater reliability of the two tester persons working simultaneously, and the results could influence with this case and so these results should be used with caution.

Conclusion

These conclusions provided reliability levels for TG, TUG and WOBB suggesting they are clinically feasible outcome measures of balance in neurological approach of sports related concussion, and more investigations recommended with using these three tools. Further studies should include a population of subjects with impairment of motor function.

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Table 1. Intra-class correlation coefficients

Measure	Intra- rater-same session (N= 133)		Intra- rater-between session (N= 64)		Inter- rater- two examiner (N= 57)	
	ICC (single)	ICC (average)	ICC (single)	ICC (average)	ICC (single)	ICC (average)
Time-up-and GO	0.764	0.895	0.7640	0.855	0.992	0.996
Tandem Gait	0.961	0.687	0.905	0.946	0.685	0.697
Walking on balance beam	0.999	0.999	0.782	0.874	0.335	0.353

Table 2. Individual trial means ± SD of trials 1-3. Time in seconds (n = 133)

Measure	Trial 1	Trial 2	Trial 3	Mean of 3 Trials
Time- up- and Go	7.2 ± 1.2	6.9 ± 1.0	6.8 ± .9	6.9 ± 1.03
Tandem Gait	13.5 ± 1.2	13.8 ± 1.1	13.5 ± 1.1	13.6 ± 1.1
Walking on balance beam	7.2 ± 1.2	6.9 ± 1.0	6.8 ± .9	6.9 ± 1.03

References:

1. Pendergrass TL, Moore JH, Gerber JP. Postural control after a 2-mile run. Military medicine. 2003; 168(11):896.
2. Deliagina TG, Orlovsky GN, Zelenin PV, Beloozerova N. Neural bases of postural control. Physiology. 2006; 21:216-225.
3. Hoark FB. Postural orientation and equilibrium: What do we need to know about neural control of balance to prevent falls? Age and Ageing. 2006; 35(S2):ii7-ii11.
4. Isles CR, Lowchoy NL, Steer M, Nitz JC. Normal values of balance tests in women aged 20- 80. American Geriatrics Society. 2004; 52:1367-1372.
5. Nishikawa K, Biewener AA, Aerts P, Ahn AN et al. Neuromechanics: An integrative approach for understanding motor control. Integrative and Comparative Biology. 2007; 47(1):16-54.
6. Desrosiers J, Hebert R, Bravo G, Dutil E. Upper- extremity motor co-ordination of healthy elderly people. Age and Ageing. 1995; 24(2):101-12.
7. Enrigt PL, Sherrill DL. Reference equations for the six-minute walk in healthy adults. Am J Respir Crit Care Med. 1998; 158: 1384 – 1387.
8. Bailes JE, Handsont V. Classification of sport- related head trauma: A spectrum of mild to severe injury. Journal of Athletic Training. 2001; 36(3): 236-243.
9. Heilbronner RL, Bush SS, Ravdin LD, Barth JT, Iverson GL et al. Neuropsychological consequences of boxing and recommendation to improve safety: A national academy of

neuropsychology education paper. Arch of Clinical Neuropsychology. 2009; 24:11-19.
10. Maccrory P, Makdissi M, Davis G, Collie A. Value of neuropsychological testing after head injuries in football. Br J Med. 2005; 39(1):i55-i63.
11. Beaumont LD, Theoret H, Mongeon D, Messier J et al. Brain function decline in healthy retired athletes who sustained their last sports concussion in early adulthood. Brain. 2009; 132:695-708.
12. Blake H, Mckinney M, Treece K, Lee E, Lincoln NB. An evaluation of screening measures for cognitive impairment after stroke. Age and Ageing. 2002; 32:451-456.
13. Barles JE, Hudsont V. Classification of sport- related head trauma: A spectrum of mild to severe injury. Athletic Training. 2001; 36(3):236-243.
14. Randolph C, Millis S, Barr WB, Mccrea M et al. Concussion symptom inventory: An empirically derived scale for monitoring resolution of symptoms following sport- related concussion. Arch of Neuropsychology Journals. 2009; 24:219-229.
15. Alla S, Sullivan SJ, Mccrory P, Schneiders AG, Handcock P. Does exercise evoke neuroligical symptoms in healty subject? Journal of Science and Medicine in Sport. 2010; 13:24-26.
16. Locklin JA. Development of a measure of visu-motor control for assessing the long- term effects of concussion. A thesis in psychology. 2004.
17. Mccrory P, Johnston K, Meeuwisse W, Aubry M et al. Summary and agreement statement of the 2nd international conference on concussion in sport, Prague 2004. Clin J Sport Med. 2005; 15(2):48-55.
18. Shuttleworth E. Central or peripheral? A positional stance in reaction to the Prague statement on the role of neuropsychological assessment in sports concussion management. Arch of Clinical Neuropsychology. 2008; 23:479-485.
19. Ebersbanch G, Sojer M, Valldeoriola F, Wissel J et al. Comparative analysis of gait in Parkinson's disease, cerebellar ataxia and subcortical arteriosclerotic encephalopathy. Brain. 1999; 122: 1349- 1355.
20. Bunchner DM, Cress ME, De Lateur BJ, Esselman PC et al. The effect of strength and endurance training on gait, balance, fall risk, and health services use in community-living older adults. Journal of gerontology: Med Sciences. 1997; 52A (4): M218- M224.
21. Morris ME, Cantwell C, Vowels L, Dodd K. Change in gait and fatigue from morning to afternoon in people with multiple sclerosis. Journal Neurol Neurosurg Psychiatry. 2002; 72: 361-365.
22. Liston R, Mickelborough J, Bene J, Tallis R. A new classification of higher level gait disorders in patients with cerebral multi-infarct states. Age and Ageing. 2003; 32: 252- 258.
23. Schlicht J, Camaione DN, Owen SV. Effect of intense strength training on standing balance, walking speed, and sit- to- stand performance in older adults. Journal of Gerontology: Med Sciences. 2001; 56A (5): M281- M286.
24. Malatesta D, Simar D, Saad HB, Prefaut C, Caillaud C. Effect of an over ground walking training on gait performance in healthy 65-80 years old. Experimental Gerontology. 2010; 45: 427- 434.
25. Martini DN. The chronic effects of concussion on gait. A Thesis, University of Illinois at Urbana-Champaign, 2010.
26. Wall JC, Bell C, Campbell S, Davis J. The timed get-up and go test revisited: Measurement of the component tasks. Journal of Rehabilitation Research and Development. 2000; 37 (1): 109- 114.
27. Schneiders AG, Sullivan SJ, Gray AR, Hammond-Took GD, Mccrory PR. Normative values for three clinical measures of motor performance used in the neurological assessment of sports concussion. Journal of Science and Medicine in Sport. 2010; 13: 196-201.
28. Giorgetti MM, Harris BA, Jette A. Reliability of clinical balance outcome measures in the elderly. Physiotherapy Research International. 1998; 3(4):274-283.
29. Bischoff HA, Stahelin HB, Monsch AU, Iversen MD et al. Identifying a cut-off point for normal mobility: a comparison of the time up and go test in community-dwelling and institutionalized elderly women. Age and Ageing. 2003; 32:315-320.
30. Isles CR, Lowchoy NL, Steer M, Nitz JC. Normal values of balance tests in women aged 20- 80. American Geriatrics Society. 2004; 52:1367-1372.
31. Povlov IY, Wilson AR, Delgado JC. Resampling of the method for reference interval calculation in clinical laboratory practice. Clinical and Vaccine Immunology. 2010; 17(8): 1217- 1222.
32. Linnet K. Nonparametric estimation of reference intervals by simple and bootstrap based procedures. Clin Chem. 2000; 46(6): 867- 90.
33. Newton BR. Balance screening of inner city older adult population. Arch Phys Med Rehabil. 1997; 78:587-91.
34. Stevens KN, Lang LA, Guralnik JM, Melzer D. Epidemiology of balance and dizziness in a national population: Findings from the English longitudinal study of ageing. Age and Ageing. 2008; 37:300-305.
35. Riemann B, Guskiewicz KM. Effects of mild head injury on postural stability as measured through clinical balance testing. Journal of Athletic Training. 2000; 35(1):19-25.
36. Schneiders AG, Sullivas SJ, Mccrory PR, Gray A et al. The effect of exercise on motor performance tasks used in the neurological assessment of sports related concussion. Br J Sports Med. 2008; 42: 1011-1013.
37. Ziaee V, Rahmani SH, Rostami M. Injury rates in Iranian Taekwondo athletes; Prospective study. Asian Journal of Sports Medicine. 2010; 1(1): 23-28.