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Original article

Correlation of the composite equilibrium score of computerized dynamic posturography and clinical balance tests

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ABSTRACT

Background: The computerized dynamic posturography has been widely used to access balance control in patients with balance dysfunction. A composite-equilibrium score (CS) can be calculated from the sensory organization test using the computerized dynamic posturography. However, the correlation between the composite equilibrium score and clinical tests and its ability to predict falls has rarely been explored in the past.
Methods: A total of 60 patients with chief complaint of dizziness were enrolled in our study, and clinical assessments were done including the sensory organization test (SOT), Timed Up and Go test (TUG), Tinetti Performance-Oriented Mobility Assessment (POMA), and the dynamic gait index (DGI). The age and the subjective feeling of the severity of dizziness quantified by the visual analog scale (VAS) of each patient were also recorded.
Results: Statistical analysis revealed significant correlation between the composite equilibrium score and the TUG, POMA (gait, balance and total scores), and the DGI. However, there is statistically significant correlation between neither the CS and the age nor the VAS of dizziness. When grouping the DGI, POMA (total score), and the TUG cutoff to predict fall risks, the correlations to the CS can still be established except the TUG.
Conclusion: From the results of our study, the validity of the clinical tests was established in assessment of balance function, and clinicians can utilize these tools for preliminary evaluation of patient balance when computerized dynamic posturography is not available. In addition, CS can be used to predict the risk of falls.

1. Introduction

Dizziness is a common complaint among all outpatients, and the prevalence is even as high as 8.3% in patients aged 65 years or older in family practice.[1] Although the prevalence of dizziness increases steadily with age,[2] young people also experience dizziness, frequently due to migraine headaches and other nonvestibular disorders.[3] Disequilibrium and imbalance are frequently encountered problems among dizzy patients. These problems should be taken seriously because they can lead to falls, injuries, loss of independence, and even death. Dizziness is also strongly associated with fear of falling,[4] and the fear of falling is in turn considered a strong predictor of a consecutive fall event, impaired functional ability, and poor quality of life.[5] A test that can provide an accurate assessment of fall risk prior to falling would allow timely intervention and lessen the tremendous medical expenditure subsequent to the falling accident.

Several clinical tests are available to evaluate the severity of imbalance and risk of falls. The dynamic gait index (DGI), which evaluates not only steady-state walking, but also walking during more challenging conditions, is a frequently used clinical tool to evaluate the gait stability and falling risk.[6] Although the DGI has been shown to be moderately correlated with several balance tests

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including the Berg Balance Test, and the Timed Up and Go Test (TUG), it is susceptible to ceiling effects.[7] Moreover, the DGI evaluates only walking, while imbalance and falls usually happen in conditions other than walking, such as transfer or rising up from chair or crouching. The Tinetti Performance-Oriented Mobility Assessment (POMA),[8] which comprises of the balance and the gait section, provides a more comprehensive approach to one's balance function. Its validity and reliability has been established to assess the falling risks in several conditions,[9,10] and the sensitivity as a predictor of fall risk is much higher than that of the functional reach test, the TUG, the DGI and the Berg Balance Scale.[9] The TUG is less time-consuming and is a test frequently used for fall risk evaluation. Some studies confirmed the value of the TUG to predict falls,[11,12] and some studies held different views.[13–15] The advantages of these clinical assessments are easy to perform, less time-consuming, and no specific testing equipment required.

By contrast, the posturography is able to quantify the postural control in upright stance in either static or dynamic conditions by use of a movable forceplate, a visual surround that can move in a sway-referenced manner, and a harness to prevent falls during testing. These devices are connected to a computer, and the amount of sway of center of mass can be transmitted and recorded in a real-time manner. A key test, called the sensory organization test (SOT), provides information about one's ability of integration of visual, vestibular, and somatosensory signals to maintain upright posture. The SOT consists of six conditions, namely (1) eyes open, surround and platform stable, (2) eyes closed, surround, and platform stable, (3) eyes open, sway-referenced surround, (4) eyes open, sway-referenced platform, (5) eyes closed, sway-referenced platform and (6) eyes open, sway-referenced surround, and platform. An equilibrium score (ES) can be computed from each of the six conditions, and a composite equilibrium score (CS) is then can be calculated from the six ES, which reflect the overall coordination ability of the visual, vestibular, and somatosensory system.[16] The computerized dynamic posturography allows to obtain a more specific quantification of the patient's balance function, but it is more time-consuming and require specific equipment, which impede it from becoming a prevalent examination for patients with imbalance.

The DGI, POMA, and the TUG have been clinically utilized for many years to evaluate the fall risk, while the computerized dynamic posturography quantifies balance function in a more specific way. However, the correlation between the CS of SOT and the three clinical tests has never been explored in the past literature. In our study, we aim to discover the correlation between them. In addition, the age and the subjective feeling of dizziness are also included to evaluate their correlation with CS. Grouping of the Tinetti total score, DGI, and TUG was also done according to their cutoff value of predicting high risk of falling, and their correlation with CS is also to be evaluated in our study.

2. Materials and methods

2.1. Study participants

This is a cross-sectional study, which collect patients' data only once with no further intervention and follow-up. From August 2007 to May 2011, all dizzy patients came to the outpatient clinics of the Department of Physical Medicine and Rehabilitation in a medical center were screened by an experienced physiatrist for participation. Diagnosis for each patient was made based on the past history, physical examinations and air-irrigation caloric test (AIRSTAR, Micromedical Technologies, Chicago, IL, USA). There were 95 patients initially. Patients not able to complete the TUG due to severe dizziness, impaired general condition, or cognitive problems were excluded, which left a total of 60 patients included. Table 1 provides the sociodemographic data of our study participants.

2.2. Clinical evaluation tools

To evaluate the falling risk and gait stability, three kinds of clinical tools were adopted in our study, including the DGI, POMA, and the TUG. The DGI was developed by Shumway-Cook and colleagues,[17] which consists of eight challenging tasks, including (1) gait on a level surface for 20 feet, (2) change in gait speed; fast then slow, (3) gait with horizontal head turns; left then right, (4) gait with vertical head turns; up then down, (5) gait and pivot turn, (6) step over obstacle (e.g., a shoe box), (7) step around obstacles, and (8) stair climbing. Each task could be given a score from 0 to 3 according to the performance presented: severe impairment record as 0 and normal record as 3. The maximum score a patient can attain on the DGI is 24, and scores of 19 or less indicate a high risk for falling in institutionalized older adults.[17]

The POMA was developed by Tinetti,[8] with nine tests included in the balance section and seven tests in the gait section. In the balance section, a patient is initially sitting in a hard, armless chair, and evaluations are done during the subsequent movements, including (1) sitting balance, (2) arise from chair, (3) attempts to rise, (4) immediate standing balance in the first 5 seconds, (5) standing balance, (6) nudged (patient's feet close together and examiner pushes lightly on the patient's sternum with palm three times), (7) eyes closed, (8) turning 360 degrees, and (9) sitting down. In the gait section, a participant initially stands with an examiner, walks initially at a usual pace and then back at a rapid but safe pace. The examiner evaluates the following gait performance, including initiation of gait, step length and height, step symmetry and continuity, path deviation, trunk sway, and walking stance. For each evaluation item, the examiner rates a score from 0 to 1, and 2 in some items. The maximum score in the balance section is 16, and that in the gait section is 12. If a participant's total scores are less than 19, then his or her falling risk is considered to be high.[8]

The TUG[18] evaluates a participant by timing while he or she rises from an armed chair, walks 3 meters, turns, walks back, and sits down again. It is quick to perform, requires no special equipment, and demands almost no training for the examiner. A past study has shown that if the time spent in TUG is 13.5 seconds or longer in a patient, the predicted falling risk will be high.[12]

The SOT, performed by a computerized dynamic posturography (Smart Balance Master, Clackamas, OR, USA), consists of a movable

Table 1
Sociodemographic data of participants.

Numbers (%)	
Sex	
Men	39(65.0)
Women	21(35.0)
Age (y)[a]	
$\geq$ 65	44(73.3)
$<$ 65	16(26.7)
Diagnosis	
Central dizziness	13(21.7)
Right side vestibular hypofunction	8(13.3)
Left side vestibular hypofunction	12(20.0)
Bilateral vestibular hypofunction	20(33.3)
Benign paroxysmal positional vertigo	5(8.3)
Meniere disease	1(1.7)
Parkinson disease	1(1.7)

[a] The youngest participant was 26 years of age and the oldest was 99 years of age. The average age of the study participants was 71.2 $\pm$ 15.6 years of age.

footplate platform, a movable surround, and a harness to prevent falling. The footplate and surround move in a sway-referenced manner, meaning that if a subject on the posturography leans forward, the footplate and/or the visual surround also tilts forward. Therefore, the posturography is able to test the participant's ability to integrate the visual, vestibular, and somatosensory inputs and to suppress sensory information that is inappropriate. The SOT requires participants to stand on the movable footplate platform to maintain balance and the six conditions mentioned before are used to challenge their balance function. Three 20-second trials are performed, and ES is calculated according to the participant's performance. A score of 100 represents no sway, while 0 indicates completely loss of balance. CS is then calculated from the six ES.

2.3. Data collection and analysis

All patients enrolled in our study underwent tests including the DGI evaluation, the POMA, the TUG, and the SOT by one assigned examiner. The degree of dizziness was also quantified by asking the participants to point out the level on a 10-degreed ruler by visual analog scale (VAS). SPSS 15.0 (SPSS Inc, Chicago, IL, USA) was adopted as our statistical tool. A Kolmogorov-Smirnov test was used initially to test the normality of the distribution. However, all of our data failed to pass the test, and therefore a nonparametric test was chosen for subsequent statistical surveys. Spearman rank correlation coefficients were calculated between the CS and age, VAS score of dizziness severity, DGI, balance score of the POMA, gait score of the POMA, total score of the POMA, and time spent in the TUG. Past literatures have shown that patients with DGI score 19 or less[16] and a Tinetti total score less than 19[8] signify higher risk of falling, while time spent in TUG 13.5 seconds or more can predict a high risk of falling.[12] To indirectly examine the correlation between CS and falling risk, the DGI, total score of POMA, and time spent in TUG were categorized according to cutoff value described above. A Mann-Whitney U-test was then used to evaluate the correlation between CS and falling risk indirectly.

3. Results

A total of 60 participants were included in our study. All of them completed each test examined by an experienced therapist. In the SOT of computerized dynamic posturography, the minimum and maximum score our participants got were 18 and 83, respectively. The mean score was 64.45, and the standard deviation was 12.6. Table 2 summarized the descriptive statistical results of the age, VAS of dizziness, DGI, time spent in TUG, balance, gait, and total score in POMA. Their correlations with CS were also shown by Spearman's correlation coefficient. Fair correlation ($r = 0.25–0.5$) was found between the CS and DGI, time spent in TUG, balance, gait and total score in POMA with statistical significance ($p < 0.05$), but the correlation failed to achieve significance in age and VAS of dizziness severity (p values were 0.271 and 0.919, respectively).

Table 2
Descriptive statistical results and the Spearman's correlation with CS.

	Minimum	Maximum	Mean	Spearman's rho	p value
Age (y)	26	99	71.22 ± 15.55	−0.144	0.271
VAS	1	10	3.53 ± 2.94	0.013	0.919
DGI	7	22	14.72 ± 3.53	0.293	0.023*
POMA-balance	5	14	9.87 ± 2.40	0.292	0.024*
POMA-gait	4	12	9.00 ± 1.97	0.389	0.002*
POMA-total	10	25	18.62 ± 3.86	0.401	0.002*
TUG	6.4	21.5	11.55 ± 0.43	−0.317	0.014*

*$p < 0.05$
CS = composite-equilibrium score; DUI = dynamic gait index; POMA = Performance-Oriented Mobility Assessment; TUG = Timed Up and Go test; VAS = visual analog scale.

The DGI, TUG, and total POMA scores were further grouped according to their cutoff value predicting high falling risk mentioned in the past studies. The DGI were grouped into score "19 or less" and "above 19." The total score in POMA were grouped into score "18 or less" and "above 18." The TUG scores were grouped into "less than 13.5 seconds" and "13.5 seconds and above." The result of subsequent Mann-Whitney U-test revealed statistically significant correlation between CS and the DGI subgroup ($p = 0.045$), and the total score in POMA subgroups ($p = 0.001$). However, the significance of correlation was not achieved between CS and the time spent in TUG subgroups ($p = 0.137$).

4. Discussion

The computerized dynamic posturography has become an important tool for assessing balance in clinical settings for dozens of years. Past studies has revealed its value in quantifying balance with various underlying diseases, such as Parkinson disease,[19] peripheral vertigo,[20] diabetes mellitus polyneuropathy,[21] and cerebellar diseases.[22] The advantage of posturography use may include (1) to make an appropriate differential diagnosis in patients with balance impairment, (2) to identify patients who are at high risk of falling, or (3) to objectively and quantitatively measure the outcome of therapeutic intervention. However, in fall-risk evaluation, previous literature showed conflicting results. One systemic literature review article included nine original prospective studies.[23] In this article, five studies revealed associations between fall-related outcomes and posturography measures, but in the remainders, associations were not found. In the five studies that supported fall and SOT relations, the mean speed, amplitude and root-mean-square value of the mediolateral movement of the center of pressure during normal standing with eyes open and closed were considered the indicators of future falls, while measurements related to dynamic posturography were considered not predictive of falls. In another study, loss of balance during the third trial in Condition 6 of SOT, which both visual and somatosensory inputs were disturbed, was considered the best predictor of recurrent falling.[24] Due to the conflicting and small number of studies, the clinical value of posturography to predict falls could still not be formally validated.[23] In our study, we evaluated the fall predicting strength of posturography by an indirect method. Since past studies have documented the cutoff value of DGI, POMA, and TUG to predict risks of fall, we made statistical analysis of Mann-Whitney U-test between the CS and subdivided groups of the above clinical tests. The result demonstrated a significant correlation between the CS and the total score of POMA group ($p = 0.001$), borderline correlation between the CS and the DGI group ($p = 0.045$), and there was no correlation between the CS and the time group in TUG ($p = 0.137$). While the POMA evaluate not only walking but also posture and balance challenges encountered in daily life, it is deemed to reflect participants' balance condition more completely than DGI and TUG, which only evaluate gait. A past study revealed that POMA is a more suitable performance measure for evaluating balance than TUG in community dwelling older people.[25] In fall-risk assessment, the sensitivity of POMA is also higher than that of DGI and TUG for individuals with Parkinson disease.[9] These results are compatible with our study, which shows highest significance of statistical correlation between the CS and total score of POMA grouped by the cutoff value 19. The CS of SOT reflects the overall coordinating ability of visual, auditory, and somatosensory systems of human body, and our study results suggested that CS is a fall predicting factor. While taking TUG scores as a predictor of falls was questioned by several studies in the past,[13–15] our study's results also revealed poor correlation between the TUG grouping and the CS. The fall prediction power of TUG is still questionable.

In our study, the Spearman's correlation data revealed no correlation between CS and age. In older people, dizziness and balance problems are more prevalent due to the following three reasons: (1) age-related decline of function of sensory and motor organs, such as loss of hair cell in the labyrinth[26] and decreased number and size of muscular fiber,[27] (2) diseases that cause motor function to decline are more prevalent in the elderly, such as stroke and Parkinson disease, and (3) medications such as tricyclic antidepressant for treatment of neuropathic pain and α-blockers for benign prostate hyperplasia which cause dizziness and balance problems are frequently prescribed to older people. However, in our study, the CS and the age are not relevant statistically. That means although aged people are more prone to have balance problems, the degree of severity is not always age-related among dizzy population. One previous study concluded that the distance of sway on posturography increased significantly with advancing age,[28] which is contradictory to the results of our study. One probable explanation lies in the difference of study population. Fujita's study[28] recruited subjects without specific neurological or metabolic disorders. In our study, on the contrary, most participants with dizziness had definite diagnosis of clinical pathology, which indicates that once patients have medical conditions causing balance problems, the degree of imbalance may be similar between the young and old aged groups.

In our study, the Spearman's correlation data revealed no correlation between CS and the severity of dizziness evaluated by the VAS. The result is similar to a past study, which demonstrated no correlation between the Dizziness Handicap Inventory (DHI) and computerized dynamic posturography testing.[29] The reason probably lies in the degree of subjective dizziness being more affected by one's mood status and anxiety level. A past study demonstrated an increased subjective impairment and healthcare utilization in a group of dizziness patient with comorbid anxiety,[30] and another study also discovered that dizziness patients with anxiety and depressive disorders showed the greatest emotional distress and handicaps.[31] In our study, more patients completed VAS. It is probably due to the fact that VAS reflects the severity of dizziness in a direct way, and less time consuming. However, part of our participants (total 37 in number) completed the DHI questionnaire, and we did the Spearman's correlation study between the CS and DHI scores from the data of the 37 patients, the correlation between them showed no statistical significance as would expected. ($r = -0.082$, $p = 0.63$).

One of the limitations of our study lies in the small sample size, which consisted of 44 elderly and 16 young patients. The small number of young participants in our study may influence the result of the correlation between age and CS. Secondly, the medication prescribed to our participants were not recorded, which may also become a confounding factor of our study results. Medications that may affect patients' balance function will be recorded in our future study for a more complete interpretation of our data. Finally, the study design is cross-sectional, and the power of the ability to predict falls by the CS is lessened due to lack of prospective data of falls. Future research may include participants' fall history for a more realistic and meaningful data interpretation in clinical practice.

5. Conclusion

The CS obtained from the computerized dynamic posturography reflects the overall balance conditions and the coordination ability of the visual, vestibular, and somatosensory systems. It correlates with several clinical tests in our study, including the DGI, POMA, and time spent in TUG. In case of the unavailability of posturography device, those clinical tests can serve as substitutes to preliminarily evaluate patients' balance function. Despite the correlation, the fall-risk prediction of the TUG cutoff failed to achieve significance. In addition, the nihility of the correlation between neither CS and age nor CS and the severity of dizziness may remind clinical practitioners one important point: The age and severity of dizziness may be independent of patients' degrees of balance problems.

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References

1. Maarsingh OR, Dros J, Schellevis FG, van Weert HC, Bindels PJ, Horst HE. Dizziness reported by elderly patients in family practice: prevalence, incidence, and clinical characteristics. *BMC Fam Pract* 2010;**11**:2.
2. Barin K, Dodson EE. Dizziness in the elderly. *Otolaryngol Clin North Am* 2011;**44**:437–54.
3. Taylor J, Goodkin HP. Dizziness and vertigo in the adolescent. *Otolaryngol Clin North Am* 2011;**44**:309–21.
4. Burker EJ, Wong H, Sloane PD, Mattingly D, Preisser J, Mitchell CM. Predictors of fear of falling in dizzy and nondizzy elderly. *Psychol Aging* 1995;**10**:104–10.
5. Li F, Fisher KJ, Harmer P, McAuley E, Wilson NL. Fear of falling in elderly persons: association with falls, functional ability, and quality of life. *J Gerontol B Psychol Sci Soc Sci* 2003;**58**:283–90.
6. Medley A, Thompson M, French J. Predicting the probability of falls in community dwelling persons with brain injury: a pilot study. *Brain Inj* 2006;**20**:1403–8.
7. Herman T, Inbar-Borovsky N, Brozgol M, Giladi N, Hausdorff JM. The Dynamic Gait Index in healthy older adults: the role of stair climbing, fear of falling and gender. *Gait Posture* 2009;**29**:237–41.
8. Tinetti ME. Performance-oriented assessment of mobility problems in elderly patients. *J Am Geriatr Soc* 1986;**34**:119–26.
9. Kegelmeyer DA, Kloos AD, Thomas KM, Kostyk SK. Reliability and validity of the Tinetti Mobility Test for individuals with Parkinson disease. *Phys Ther* 2007;**87**:1369–78.
10. Kloos AD, Kegelmeyer DA, Young GS, Kostyk SK. Fall risk assessment using the Tinetti mobility test in individuals with Huntington's disease. *Mov Disord* 2010;**25**:2838–44.
11. Kristensen MT, Foss NB, Kehlet H. Timed "up & go" test as a predictor of falls within 6 months after hip fracture surgery. *Phys Ther* 2007;**87**:24–30.
12. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. *Phys Ther* 2000;**80**:896–903.
13. Thrane G, Joakimsen RM, Thornquist E. The association between timed up and go test and history of falls: the Tromso study. *BMC Geriatr* 2007;**7**:1.
14. Large J, Gan N, Basic D, Jennings N. Using the timed up and go test to stratify elderly inpatients at risk of falls. *Clin Rehabil* 2006;**20**:421–8.
15. Lindsay R, James EL, Kippen S. The Timed Up and Go Test: unable to predict falls on the acute medical ward. *Aust J Physiother* 2004;**50**:249–51.
16. Chaudhry H, Bukiet B, Ji Z, Findley T. Measurement of balance in computer posturography: comparison of methods–A brief review. *J Bodywork Mov Ther* 2011;**15**:82–91.
17. Shumway-Cook A, Baldwin M, Polissar N, Gruber W. Predicting the probability for falls in community-dwelling older adults. *Phys Ther* 1997;**77**:812–9.
18. Podsiadlo D, Richardson S. The timed 'up and go': a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc* 1991;**39**:142–8.
19. Ebersbach G, Gunkel M. Posturography reflects clinical imbalance in Parkinson's disease. *Mov Disord* 2011;**26**:241–6.
20. Zhang D, Fan Z, Yu G, Wang H. The clinical value of dynamic posturography in the peripheral vertigo. *Lin Chung Er Bi Yan Hou Tou Jing Wai Ke Za Zhi* 2009;**23**:721–3. 727.
21. Emam AA, Gad AM, Ahmed MM, Assal HS, Mousa SG. Quantitative assessment of posture stability using computerised dynamic posturography in type 2 diabetic patients with neuropathy and its relation to glycaemic control. *Singapore Med J* 2009;**50**:614–8.
22. Baloh RW, Jacobson KM, Beykirch K, Honrubia V. Static and dynamic posturography in patients with vestibular and cerebellar lesions. *Arch Neurol* 1998;**55**:649–54.
23. Piirtola M, Era P. Force platform measurements as predictors of falls among older people - a review. *Gerontology* 2006;**52**:1–16.

24. Buatois S, Gueguen R, Gauchard GC, Benetos A, Perrin PP. Posturography and risk of recurrent falls in healthy non-institutionalized persons aged over 65. *Gerontology* 2006;**52**:345–52.
25. Lin MR, Hwang HF, Hu MH, Wu HD, Wang YW, Huang FC. Psychometric comparisons of the timed up and go, one-leg stand, functional reach, and Tinetti balance measures in community-dwelling older people. *J Am Geriatr Soc* 2004;**52**:1343–8.
26. Rosenhall U, Rubin W. Degenerative changes in the human vestibular sensory epithelia. *Acta Otolaryngol* 1975;**79**:67–80.
27. Faulkner JA, Larkin LM, Claflin DR, Brooks SV. Age-related changes in the structure and function of skeletal muscles. *Clin Exp Pharmacol Physiol* 2007;**34**:1091–6.
28. Fujita T, Nakamura S, Ohue M, Fujii Y, Miyauchi A, Takagi Y, et al. Effect of age on body sway assessed by computerized posturography. *J Bone Miner Metab* 2005;**23**:152–6.
29. Robertson DD, Ireland DJ. Dizziness Handicap Inventory correlates of computerized dynamic posturography. *J Otolaryngol* 1995;**24**:118–24.
30. Wiltink J, Tschan R, Michal M, Subic-Wrana C, Eckhardt-Henn A, Dieterich M, et al. Dizziness: anxiety, health care utilization and health behavior–results from a representative German community survey. *J Psychosom Res* 2009;**66**:417–24.
31. Eckhardt-Henn A, Breuer P, Thomalske C, Hoffmann SO, Hopf HC. Anxiety disorders and other psychiatric subgroups in patients complaining of dizziness. *J Anxiety Disord* 2003;**17**:369–88.