Reliability of Quantitative Static and Dynamic Balance Tests on Kinesthetic Ability Trainer and Their Correlation with Other Clinical Balance Tests

Kinestetik Beceri Eğitim Cihazında Uygulanan Kantitatif Statik ve Dinamik Denge Testlerinin Güvenilirliği ve Diğer Klinik Denge Testleriyle Korelasyonu

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ABSTRACT

Objective: DWe aimed to evaluate the reliability of the balance tests performed on Kinesthetic Ability Trainer 3000 (KAT 3000) and their correlations with commonly used clinical balance tests in healthy volunteers.

Methods: Fifty healthy volunteers (31 women, 19 men) aged 41.7 years were included in the study. KAT 3000 (Med-Fit Systems Inc., Fallbrook, C.A., USA) was used to measure static and dynamic balance of participants. Additionally, from the standardized clinical balance tests; timed up and go test (TUG), four square step test (FSS) and Berg balance scale (BBS) were preformed to all subjects. Three weeks after completion of all the tests, 31 volunteers repeated the balance tests measured on KAT.

Results: Moderate correlation was found between static (SBI) and dynamic balance indexes (DBI) (r=0.51, p<0.001). SBI was strongly correlated with BBS (r=-0.71, p<0.001) and moderately correlated with FSS and TUG tests (r=0.33, p<0.05 and r=0.42, p<0.001, respectively). The correlation of DBI with BBS was moderate (r=0.53, p<0.001), whereas there was weak correlation with TUG and no correlation with FSS. Intraclass correlation coefficient were 0.90 and 0.87 for SBI and DBI.

Conclusion: Static and dynamic balance tests on KAT are reliable in healthy individuals. The correlations of SBI with BBS, TUG and FSS were stronger than that of DBI. This method can be used more prevalently to evaluate balance ability. *(J PMR Sci 2010;13:1-5)*

Keywords: Kinesthetic Ability Trainer, balance tests, reliability, four square step test, timed up and go test

ÖZET

Amaç: Bu çalışmada, sağlıklı gönüllülerde Kinestetik Beceri Eğitim 3000 (KBE 3000) cihazında uygulanan denge testlerinin güvenilirliğini ve bu testlerin yaygın olarak kullanılan klinik denge testleriyle korelasyonlarını değerlendirmeyi amaçladık.

Yöntemler: Çalışmaya ortalama yaşı 41,7 olan 50 sağlıklı gönüllü (31 kadın, 19 erkek) dahil edildi. Katılımcıların statik ve dinamik denge ölçümleri için KBE 3000 (Med-Fit Systems Inc., Fallbrook, C.A., USA) cihazı kullanıldı. Ayrıca, tüm olgulara standize edilmiş klinik denge testlerinden zamanlı ayağa kalkma ve yürüme testi (ZAYT), dört kare adım testi (DKAT) ve Berg denge skalası (BDS) uygulandı. Testlerin uygulanmasından 3 hafta sonra, 31 gönüllü KBE cihazında uygulanan denge testlerini tekrarladı.

Bulgular: Statik (SDİ) ve dinamik denge indeksleri (DDİ) arasında orta derecede korelasyon saptandı (r=0,51, p<0,001). Statik denge indeksi, BDS ile güçlü derecede (r=-0,71, p<0,001), DKAT ve ZAYT ile orta derecede korele idi (sırasıyla, r=0,33, p<0,05 ve r=0,42, p<0,001). Dinamik denge indeksi'nin BDS ile arasındaki korelasyonu orta (r=0,53, p<0,001), ZAYT ile arasındaki korelasyonu zayıf olarak bulundu, DKAT ile arasında korelasyon yoktu. İntraklas korelasyon katsayıları SDİ için 0,90, DDİ için 0,87 idi.

Sonuç: Sağlıklı gönüllülerde KBE cihazında uygulanan statik ve dinamik denge testleri güvenilir olarak saptandı. Statik denge indeksi'nin BDS, ZAYT ve DKAT ile olan korelasyonları DDİ'nin klinik denge testleriyle olan korelasyonlarından daha güçlü bulundu. Bu metod denge yeteneğini değerlendirmede daha yaygın olarak kullanılabilir. *(FTR Bil Der 2010;13:1-5)*

Anahtar kelimeler: Kinestetik Beceri Eğitim cihazı, denge testleri, güvenilirlik, dört kare adım testi, zamanlı ayağa kalkma ve yürüme testi

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Introduction

Balance is the ability to maintain body's center of gravity vertically above the base of support, which comprises the area of the feet and the ground between them (1). It is essential to control center of gravity during standing still, perturbed standing and performing functional tasks of activities of daily living (ADL) successfully (2). Balance depends on central processing of visual, vestibular and sensorimotor inputs of the afferent mechanisms and corresponding purposeful neuromuscular action of the efferent mechanisms (1). These sensory systems provide information about the positions of head and body segments relative to the environment (3). Balance control may require a continuous regulation and integration of sensory inputs: rapidity and efficiency of these high-level processes depend upon the integrity of the peripheral systems and balance requirements (4). Impairments of any of these components may result in impaired balance and mobility. This, in turn, may result in unskillful performance of ADL and increase risk for falls (3). This is substantially critical for physiatrists since balance impairments should be identified during a comprehensive evaluation of the patient. Exercises that improve balance and coordination may be incorporated into the rehabilitation program of these patients. Balance measurement is also of value in the assessment of the benefits of the treatment.

There are many assessment tools used for evaluation of balance; however none of them has been proven to be gold standard. Balance tests should take as short time as possible and be reliable and quantifiable for follow up of changes in balance. There are simple clinical balance tests that can be performed in the physical examination. These are well standardized and highly reliable clinical assessment tools. Tinetti gait and mobility scale, Berg balance scale, timed up and go test, four square step tests are examples for these clinical tests. Another group of balance tests that are supported with computers are used in the laboratory settings for research purposes mostly because of their high cost and lack of portability (5). Deciding in which one of these tests will be performed depend on multiple factors such as characteristics of population, cost and time.

Kinesthetic Ability Trainer (KAT) is a balance platform designed for improving proprioception. Advanced versions supported by computers can also be used to assess static and dynamic balance as well as exercise training.

The aim of this study was to determine the reliability of the balance tests performed on KAT 3000 and their correlations with commonly used clinical balance tests in healthy volunteers.

Materials and Methods

Participants

Fifty healthy volunteers were enrolled in the study that was carried out at Department of Physical Medicine and Rehabilitation. This study was approved by the ethics committee of Gazi Hospital, Gazi University Faculty of Medicine. After informed consent was obtained, participants completed a questionnaire about sociodemographic features, systemic diseases, and current prescribed medications. Evaluation of locomotor system and neurological examination

Figure 1. The subject stands on the platform during balance measurement on Kinesthetic ability trainer

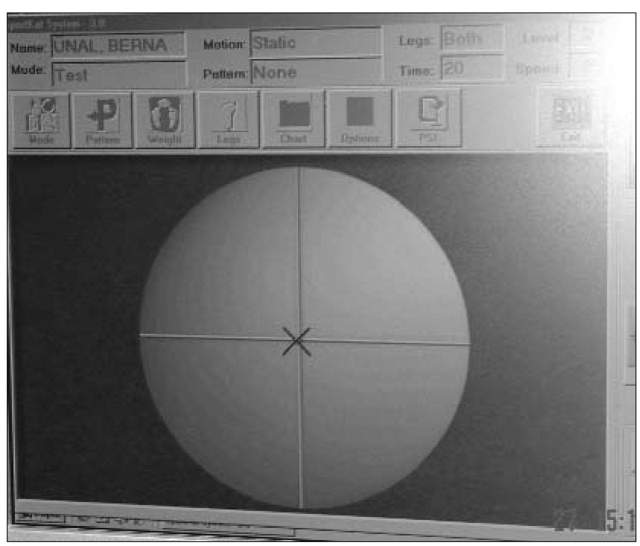

Figure 2. Computer screen of the KAT gives feedback information during the test

were performed. Subjects that have musculoskeletal diseases such as arthritis or joint replacements in the lower extremity, neurological diseases such as peripheral neuropathy, stroke or Parkinson disease, impaired vision, vestibular abnormalities or any other disease or medications that may account for balance-related problems were excluded from the study.

Procedure

To measure balance ability, Kinesthetic Ability Trainer 3000 (KAT 3000) (Med-Fit Systems Inc., Fallbrook, C.A., USA) was used (Figure 1). KAT 3000 has two main components; movable platform with an inflatable cushion underneath and tilt sensor connected to the computer. The pressure of the cushion can be changed in order to modify the difficulty of the test. The movements of the platform are perceived by the tilt sensor and transferred to the computer.

Two different protocols were used; static and dynamic. For both of the tests, the subjects were asked to stand barefoot on the platform with the feet positioned as described by the manufacturer. Arms were folded across the chest to prevent their contribution to the balance. The subject can tilt the movable platform in all directions to maintain his balance, without changing the position of his feet.

Computer screen was positioned directly in front of the subject to provide a concurrent biofeedback of the subject's position (Figure 2). The subjects were informed that the red 'X' mark on the screen was representing the center of the platform. During the static test, the subject was asked to maintain the red 'X' mark in the middle of the screen. In the dynamic test, the subject was asked to superimpose the 'X' mark onto the moving cursor which is making a 360° circle on the screen. Before starting the test, the subject was allowed to practice to become accustomed to the procedure. Each test -static and dynamic- lasted for 30 seconds and repeated for 3 times and best of the 3 scores was regarded as the final score of the subject.

From the standardized clinical balance tests; timed up and go test (TUG), four square step test (FSS) and Berg balance scale (BBS) were performed to all subjects.

Timed up and go test measures the time taken to stand from a back-supported chair, walk 3 m at a comfortable pace, turn, walk back to the chair and sit down (6).

Four square step test is a new clinical measure of rapid stepping over low obstacles and rapid changes in movement direction. Using 4 canes resting flat on the floor, the squares were formed. The subjects instructed to step forward, backward and sideway directions as fast as possible in the determined sequence (7). To make familiar with the test, one practice trial was allowed after explaining and showing the test to the subject. If the subjects failed to complete the sequence in the correct way, failed to protect his balance or had contact with any of the canes on the floor, the test procedure was repeated. The time taken to complete the sequence was recorded in seconds.

Berg balance scale, an instrument for functional balance assessment, was used to measure the balance ability while performing different activities commonly used in daily living. The test consisted of 14 items, each scored from 0 if inability to perform the task to 4 if perform the task safely and independently. Scores of all items were summed to obtain the total score (6).

Approximately three weeks after completion of all the tests, 31 volunteers (18 women, 13 men) who accepted to continue to the second part of the investigation repeated the balance tests on KAT.

The data were analyzed using SPSS 10.0 for Windows. All balance scores were recorded as means and standard deviations. To compare scores of different balance tests among each other, pearson correlation test was used. The two-way random effect model, single measure ICC and 95% CI (ICC2,1) were used to determine the test-retest reliability of static and dynamic balance tests on KAT.

Significance level was set at $p<0.05$.

Results

Fifty healthy volunteers (31 women, 19 men) aged 41.7 years (30-52 years) were enrolled in this study. Mean height and weight of the subjects were 164.2 cm (150.0-193.0 cm) and 69.7 kg (45.0 kg-105.0 kg), respectively.

Mean static and dynamic balance indexes were 300.2±116.8 and 2450.9±866.6, respectively. Mean scores of BBS, FSS and TUG tests were 55.0±1.2, 9.1±1.8 sec, and 5.7±1.0 sec, respectively.

Moderate correlation was found between static and dynamic balance indexes ($r=0.51$, $p<0.001$). Static balance index was strongly correlated with BBS ($r=-0.71$, $p<0.001$) and moderately correlated with FSS and TUG tests ($r=0.33$, $p<0.05$ and $r=0.42$, $p<0.001$, respectively). The correlation of

Table 1: Correlation of static and dynamic balance tests performed on KAT with other clinical balance tests

	Dynamic balance index (KAT)	Berg balance score	Four square step test (sec)	Timed up and go test (sec)
Static balance index (KAT)	0.51**	-0.71**	0.33*	0.42**
Dynamic balance index (KAT)	-	-0.53**	0.12	0.29*
Berg balance score	-	-	-0.49**	-0.54**
Four square step test (sec)	-	-	-	0.76**

KAT: kinesthetic ability trainer.
*p<0.05
**p<0.001

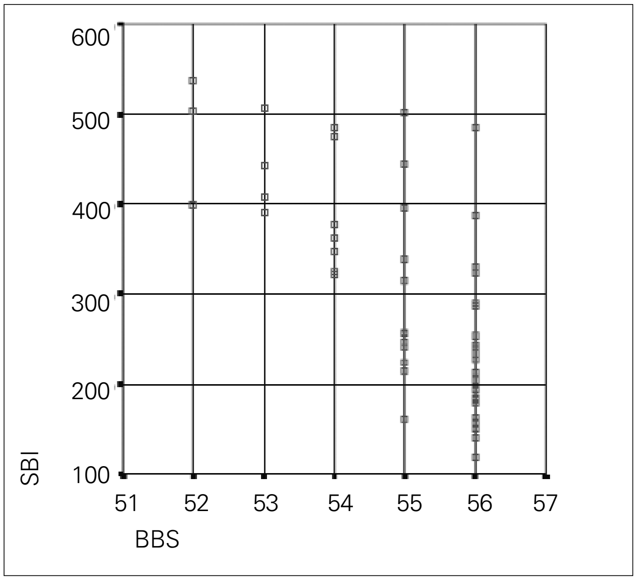

Figure 3. Scatter plot for the correlation between static balance index (SBI) and Berg balance scale (BBS)

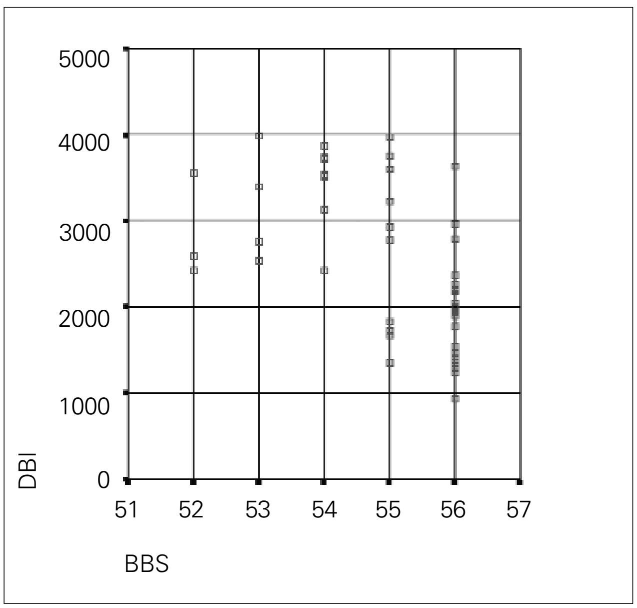

Figure 4. Scatter plot for the correlation between dynamic balance index (DBI) and Berg balance scale (BBS)

Table 2: Intraclass correlation coefficients of static and dynamic balance tests performed on KAT

	Initial mean±SD	Three weeks after mean±SD	ICC (95% CI)
Static balance index (KAT)	293.2±117.2	300.8±127.8	0.90 (0.80-0.96)
Dynamic balance index (KAT)	2363.8±936.7	2273.3±895.2	0.87 (0.73-0.94)

KAT: kinesthetic ability trainer
SD: standard deviation
ICC: Intraclass correlation coefficient
CI: Confidence interval

dynamic balance index with BBS was moderate (r=0.53, p<0.001), whereas there was weak correlation with TUG and no correlation with FSS (Table 1). Scatter plots for the correlations of BBS with SBI and DBI are given in Figure 3 and 4.

Intraclass correlation coefficients were 0.90 and 0.87 for static and dynamic balance indexes (Table 2).

Discussion

Falls are troublesome situations and may result in serious health and economic issues (8). Majority of falls are caused by balance and mobility disorders. In order to prevent falls and improve balance, it is important to determine the subjects at risk. Comprehensive physical examination of a patient in physical medicine and rehabilitation practice should include assessment of balance. This evaluation can be detailed with specific balance tests, especially in case of any suspicion of balance disorders.

Daily living activities such as standing, forward bending, walking that cause shifting of body's center of gravity require static and dynamic balance. From a functional point of view, balance may be divided into three categories: maintenance of a position, postural adjustment to voluntary movements and reaction to external disturbances (3,4).

There are numerous measures to determine balance and mobility disorders (6). These measurements are predominantly performed in clinical screening programs and epidemiological researches that investigate subjects at high risk for falls. Effectiveness of treatment modalities and potential side effects of drugs on balance ability can also be assessed by these tests (9-12).

Balance measurements are performed by clinical balance tests or laboratory tests. Laboratory tests such as force platform techniques give the physician more sensitive information about postural ability. In spite of this advantage of laboratory tests, their utilization is limited in clinical practice because of high cost, consumption of time and need of experience to perform and evaluate the test. Also, these devices need regular calibration procedures. However, tests performed on KAT balance platform are more economic and easier to operate. There are some studies using KAT to assess balance and proprioception (13,14). On the other hand, the information on the reliability of the test is inadequate and its correlation with other balance tests is not yet studied. The reliability of KAT 2000 was only evaluated on healthy physically active volunteers (15). They suggested using KAT for testing groups of persons rather than single persons due to the great variance observed in the test results.

In the present study, we investigated the test-retest reliability of static and dynamic balance tests on KAT-3000 and their correlations with clinical balance tests that are shown to be valid and reliable. We demonstrated that static and dynamic balance tests on KAT are reliable in healthy individuals.

If balance measurements are performed in patients with balance disorders, the correlations between balance tests can be even higher than that of healthy subjects since higher variations in measures are expected in these subjects.

Additionally, reliability measures of balance tests on KAT found in our study are similar to the reliability results carried out for force platform tests. Ageberg et al found that ICC values for most of the stabilometric variables were between 0.79 and 0.95 (16).

Hansen et al found learning effect on balance tests performed on KAT 2000 in sports active healthy adults (15). In our study, balance indexes on KAT did not improve with repeated measurements. This different result may be caused by the different characteristics of the study populations and the test protocols used. The mean age of the study participants in our study were approximately 10 years older than that of Hansen et al's study and were not actively engaged with any kind of sports. In that study, the static balance of subjects was tested while standing on one foot, however we measured static and dynamic balance on both feet.

Thapa et al found that biomechanical measures of balance were not correlated with clinical balance tests in elderly subjects (9). However Berg et al showed moderate correlation between postural sway and Berg balance score (17). Similarly, Lichstein et al demonstrated that Tinetti mobility index had moderate correlation with postural sway measured on force platform and strong correlation with videotaped measures of gait (18).

In the present study, balance indexes measured on KAT were correlated with clinical balance tests used. The correlations of static balance index with BBS, TUG and FSS were stronger than that of dynamic balance index. This may have resulted from the difficulty of the dynamic test procedure.

There are some limitations in our study. One of the limitations is the small number of the study population. The second one is that the results can not be generalized to patients with balance or any disorders since population of the present study consisted of only healthy subjects.

Our results demonstrated that balance assessments on Kinesthetic Ability Trainer are reliable. This technique is also more economical and easier to apply than force platforms. Quantitative and objective data can be obtained from this method, we suggest that it can be used more prevalently in the evaluation of balance ability.

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