Functional Stability Hand Tasks, what to Measure?

Fonksiyonel Stabilite El İşleri; Neyi Ölçmeli?

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ÖZET

Amaç: Ayakta durma sırasında stabilite sabit durma ya da farklı el işleri sırasında ölçülebilir. Maalesef literatürde fonksiyonel stabilite ve buna yönelik kullanılabilecek parametrelerin geçerlilikleri hakkında yeterli veri yoktur. Bu nedenle stabiliteyi ölçmek için kullanılan parametrelerin geçerliliği amaçlanmıştır.

Gereç ve Yöntem: Farklı el işlerinin uygulanması sırasında zaman ve basınç merkezi(COP) salınımı ilişkili parametrelerin geçerliliği için 20 normal denek grubu çalışmaya dahil edildi. Test aynı prosedür ile 1 gün sonra tekrar edildi. Parametrelerin güvenirliği Pearson korelasyon (PC) ve sınıflar arası korelasyon katsayısı (ICC) ile test edildi.

Bulgular: Araştırmanın sonuçları zaman ilişkili parametrelerin geçerliliğinin COP yer değiştirmesi ile ilişkili olanlardan daha iyi olduğunu gösterdi. PC ve ICC korelasyonları sırasıyla 1,375-0,947 ve 0,53-0i917 arasında değişmekte idi.

Sonuç: Fonksiyonel stabilite kuvvet platformu ile ölçülebilir. Her ne kadar fonksiyonel stabiliteyi değerlendirmek için mediolateral ve anteroposterior düzlemlerde COP yer değiştirme miktarı ve farklı el uğraşlarını gerçekleştirmek için gerekli zaman kullanılabilirse de zaman ilişkili parametrelerin geçerliliği COP yer değiştirme parametrelerinden daha iyidir. *(FTR Bil Der 2012;15: 7-11)*

Anahtar kelimeler: Fonksiyonel stabilite, basınç merkezi, salınım

ABSTRACT

Objective: The stability during standing can be measured during quiet standing and by undertaking different hand tasks. Unfortunately there is a lack of information in the literature regarding the evaluation of the functional stability and validity of the parameters that can be used in this regard. Therefore, it was aimed to find the reliability of the parameters used to measure the stability.

Methods: A group of 20 normal subjects were recruited to check the validity of time and centre of pressure (COP) sway based parameters during performing various hand tasks. The test was repeated using the same procedure after one day. The reliability of the parameters was tested by Pearson correlation (PC) and Interclass correlation coefficients (ICC).

Results: The results of the research showed that the validity of the time based parameters was more than those that were COP excursion based. The PC and ICC correlations varied between 0.375 and 0.947, 0.53 and 0.917, respectively.

Conclusion: The functional stability can be measured by using force plate. Although measuring the excursion of the COP in both mediolateral and anteroposterior planes and the time of undertaking various hand tasks can be used to evaluate the functional stability, the validity of the time based parameters was more than COP excursion (1) parameters. *(J PMR Sci 2012;15: 7-11)*

Keywords: Functional stability, COP, Sway

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Geliş Tarihi/Received: 07.01.2012
Kabul Tarihi/Accepted: 09.04.2012

Introduction

Stability during standing is achieved by a complex process that involves the function of musculoskeletal and neurological systems. There are two methods that can be used for measuring stability; these include measuring the stability during quiet standing and during performing various hand tasks. Measuring the centre of pressure (COP) during various conditions such as single and double limb supports can be achieved by use of a force plate, which provides accurate information about postural control through calculation of COP or the point of application of force distributed under the feet (1-5). Postural sway can also be measured by use of accelerometer placed at the back of subjects. Three axial accelerometer has been used to obtained postural sway projected on a level surface, which is more sensitive to the difference of test conditions (6-9). However, there is a moderate correlation between trunk acceleration and COP parameter obtained from force plate (6).

The stability of normal and handicapped subjects during quiet standing was evaluated in many research studies however, there is insufficient studies regarding stability during performing functional tasks (5). It involves complication of various hand tasks which represent the performance of proprioception, range of motion, strength of muscles and also the ability of the subjects to remain steady and upright. The star excursion balance test (SEBT) and balance error scoring (BESS) are the two cost effective and useful tests which can be used to represent stability dynamically (5,10).

Unfortunately, it is not possible to use the aforementioned tests for handicapped subjects such as for cerebral palsy and spinal cord injury (SCI) individuals. Johnson hand function test is one of the dynamic tests used for analyzing stability during hand function. The test was extended to include tasks which included vertical reaching and crossing the midline whilst standing. This test measures both fine and gross motor skills. Triolo et al (1993) evaluated the functional stability of 69 able bodies and two paraplegic subjects whilst they undertook different hand tasks including moving a small countertop, lifting objects up to lower shelf, lifting objects from lower to a higher shelf, and pushing objects using the dominate side. The time required to do these tasks was the main factor selected for final analysis. The results obtained from the SCI subjects showed that more work must be done to check the reliability in both normal and paraplegic subjects (11). They also reported that the reliability of time for vertical reaching tasks was between 0.44 and 0.96. For transverse reaching tasks the reliability varied between 0.47 and 0.93.

In another research study carried out by Baardman et al (1997) the stability of a group of paraplegic subjects during undertaking various hand tasks was evaluated. They asked subjects to stand in front of a table that was positioned at their preferred workbench height. The time necessary to perform various hand tasks and crutch axial force were selected for final analysis (12). Middleton et al were the other researchers measured the stability of normal and paraplegic subjects during doing different hand tasks. They used some parameters such as the amplitude of the COP sways in the anteroposterior and mediolateral directions (13).

Although, in the above mentioned research the stability was evaluated by use of functional hand tasks, in none of them the reliability of the COP and time based parameters were evaluated. Therefore, the main aim of this research study was to check the reliability of various parameters which can be used to represent the stability of the subjects dynamically.

Method

Subjects: A group of 20 normal subjects participated in this study. The main criteria to select the subjects were having no medical history of stability disorders and any contraindication to stand and walk. Table 1 shows the characteristics of the subjects that selected for this research study.

Equipment: The experimental set up consisted of a Kistler force plate 9366AB (40 *60 cm) and a Kistler 5017A amplifier. The force plate was used to measure the centre of pressure which is considered to be a good approximation of sway. Sway during standing is defined by movements of Centre Of Gravity (COG) in a horizontal plane (14, 15). A digital watch was used to record the time of undertaking various hand tasks.

Parameters: The time required doing the transverse and vertical reaching tasks and the excursion of the COP sways, the square root of mean of the squares of COP amplitude (RMS) and the area under COP sway curve (AUC) in the mediolateral and anteroposterior directions were selected for final analysis.

Procedure: The subjects were asked to stand in front of a table (wide 80 cm, depth 60 cm) with the heights equal to between 5 and 10 cm below the iliac crest. They were requested to move five cylindrical weights marked with five different colors, with mass, height, and diameter equal to 0.25 kg, 5 cm and 5 cm, respectively. They were positioned approximately 15 cm apart from left to right on five different colored circles. From the back side the colored circles were inserted with the same distance but in reverse order. For the second part of the test a small table was used with a height of 20 cm for analyzing the stability during vertical reaching. This small table was located 25 cm behind the edge of the main table.

Data were acquired with subjects in double leg stance with feet at pelvic width during normal standing. Five successful trials were recorded in this research project at a frequency of

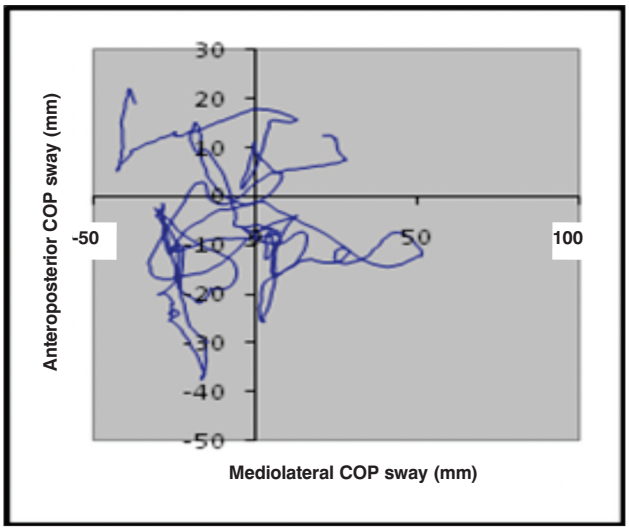
Table1. The information of the subjects who participated in this study

Parameters	Age (year)	Mass (kg)	Height (m)
Mean value	26±2.4	74±10	1.75±0.04

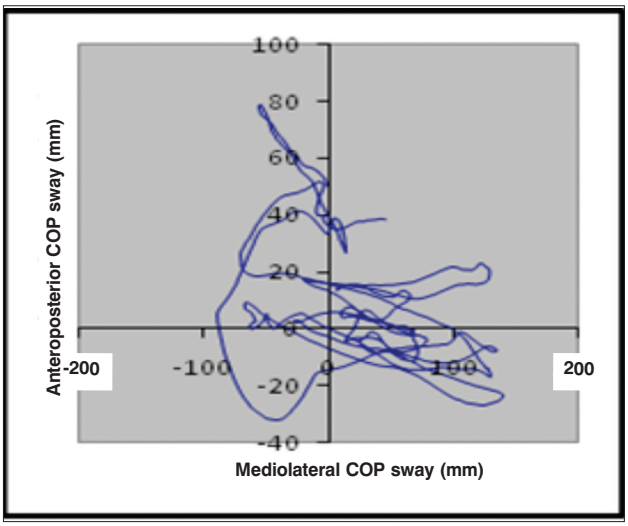
120 Hz. The signal of the force plate was filtered with a Butterworth low-pass filter with cut off frequency of 10 Hz. The subjects were instructed to stand on the force plate and then after achieving appropriate level of stability were asked to move the weights from left to right to the corresponding colors on the back side as quickly as possible and back again from right to left. In this way the anteroposterior and mediolateral COP sways and also the time necessary to complete the tasks were recorded. The test was repeated in order to collect 5 successful trials.

In the second part of the test a small table was located on top and 25 cm behind the edge of the main table and the subjects were asked to lift cylindrical weights and put them on top of the small table, without considering the colors and the location, and then return them to their first positions. The same parameters were collected and the tests were repeated a total of 5 times.

The normal distribution of the aforementioned parameters was evaluated by use of Shapiro-Wilk test with a significant point as 0.05. Since the parameters had a normal distribution, parametric tests were used for final analysis.



Şekil 1. The COP excursion in the mediolateral and anteroposterior planes during transverse motion



Şekil 2. The COP excursion in the mediolateral and anteroposterior planes during vertical motion

Table 2. The information of the subjects who participated in this study

Parameters	Mean values (First time)	Mean values (second time)
Time for transverse motion (S)	10.33±1.22	9.6±1.2
COP excursion in AP plane, transverse motion (mm)	69.8±13.9	70.5±11.9
COP excursion in ML plane, transverse motion (mm)	175±60.4	171.5±67.27
Time for vertical Motion (S)	9.5±1.31	9±1.4
COP excursion in AP plane, vertical motion (mm)	48±16.21	46.7±10.95
COP excursion in ML plane, vertical motion (mm)	50.98±14.9	55±43
RMS in the anteroposterior direction, transverse motion (mm)	45.87±12.4	36.6±20.8
RMS in the mediolateral direction, transverse motion (mm)	175.54±234	89.77±101
AUC in the anteroposterior direction, transverse motion (mm)	338.99±272.4	259.92±267
AUC in the mediolateral direction, transverse motion (mm)	284.64±172.13	150.32±34.36
RMS in the anteroposterior direction, vertical motion (mm)	24.13±6.72	15.35±4.9
RMS in the mediolateral direction, vertical motion (mm)	80.15±95	55.83±63
AUC in the anteroposterior direction, vertical motion (mm)	44.72±82.83	79.127±66.74
AUC in the mediolateral direction, vertical motion (mm)	146.65±46	98.99±33.33

Table 3. The Pearson and ICC correlation of the parameters used for measuring functional stability

Parameters	Pearson correlation	P-value for Pearson correlation	ICC correlation	P- value for ICC correlation
Time for transverse motion (second)	0.947	0.00	0.899	0.00
COP excursion in the AP plane (transverse motion) (mm)	0.355	0.175	0.53	0.156
COP excursion in the ML plane (transverse motion) (mm)	0.922	0.00	0.96	0.00
Time for vertical motion (second)	0.895	0.00	0.917	0.00
COP excursion in the AP plane (vertical motion) (mm)	0.694	0.013	0.799	0.016
COP excursion in the ML plane (vertical motion) (mm)	0.759	0.005	0.66	0.072
RMS in the anteroposterior direction, transverse motion (mm)	0.707	0.182	0.7	0.2
RMS in the mediolateral direction, transverse motion (mm)	0.969	0.006	0.97	0.005
AUC in the anteroposterior direction, transverse motion (mm)	0.986	0.002	0.97	0.006
AUC in the mediolateral direction, transverse motion (mm)	0.154	0.804	0.2	0.9
RMS in the anteroposterior direction, vertical motion (mm)	0.54	0.07	0.51	0.08
RMS in the mediolateral direction, vertical motion (mm)	0.99	0.01	0.93	0.015
AUC in the anteroposterior direction, vertical motion (mm)	0.96	0.01	0.9	0.02
AUC in the mediolateral direction, vertical motion (mm)	0.776	0.06	0.72	0.055

Results

The excursions of COP during performing transverse and vertical motions hand tasks are shown in figure 1 and 2, respectively. The mean values of time and COP related parameters during the first and second sessions are shown in table 2. As can be seen the excursion of the COP in the mediolateral plane during transverse reaching task was more than that of the COP in the anteroposterior plane. In contrast the excursions of the COP in the mediolateral and anteroposterior planes were 50.98-55 mm and 46.7 and 48 mm, respectively. The time required to do the transverse and vertical reaching tasks varied between 9 and 10.33 seconds.

The mean value of RMS in the anteroposterior direction varied between 36.6±20.8 and 45.88±12.4 mm for transverse motion. In contrast it varied from 89.77±101 to 175.54±234 mm in the mediolateral direction. There was a significant correlation between RMS in the mediolateral direction of the first and second times (r=0.969, p-value= 0.006). Table 2 shows the mean values of other stability parameters used in this study.

The result of the Pearson and ICC correlations showed that the reliability of time to represent functional stability is greater than that of the COP parameters. The reliability of the COP excursion in the mediolateral plane was greater than that of the anteroposterior plane for both transverse and vertical motions. The reliability correlation of RMS in the anteroposterior and mediolateral directions was 0.707 and 0.969, respectively for transverse motion. Table 3 shows the results of the Pearson and ICC correlations.

Discussion

Functional stability test is one of the stability tests which have been used by many investigators, to evaluate the performance of the handicapped subjects during standing while undertaking various hand tasks. Although many researchers have used functional stability tests for measuring the performance of orthoses, none of them have evaluated the reliability of the selected parameters. Therefore, this research was done to find the most reliable parameters which can be used to evaluate the stability of subjects while undertaking various hand tasks.

The excursion of the COP was one of the parameters which were used in this study. The excursion of the COP in the anteroposterior plane, while undertaking transverse motion, is less than that in the mediolateral plane (it was between 69.8-70.5 mm and 46.7-48 mm for transverse and vertical reaching tasks, respectively). The main reason is that the subjects moved the cylindrical weights mostly in the mediolateral direction. Therefore, it is expected that the movements of the centre of gravity (COG) in the transverse plane be more than that in the anteroposterior plane. As the mean value and standard deviation of the COP excursion in the transverse plane is more than that in the anteroposterior plane, it represents the stability of the

subjects better than the anteroposterior COP sway. The excursions of the COP in the both planes during doing vertical reaching tasks was less than that while doing transverse reaching tasks. Therefore, it can be concluded that the transverse reaching task can show the influence of treatment or orthotic interventions better than that of the vertical tasks.

The RMS in both planes was the other selected parameter in this study. As can be seen from table 3, the reliability of RMS in the mediolateral direction was more than that in anteroposterior plane for both vertical and transverse reaching tasks. In contrast, the reliability of AUC in the anteroposterior plane was more than that of mediolateral direction. Therefore, it is recommended to use the RMS and AUC parameters for mediolateral and anteroposterior planes, respectively. The AUC and RMS parameters were used to assess the stability of normal and subjects with stroke during sit to stand tasks by use of accelerometer in another study (9). It has been shown that AUC appeared to be more sensitive than the RMS parameter.

It is clear from table 3 that for transverse reaching hand task the reliability of time and the cop excursion in the mediolateral plane is more than 0.9. Therefore it can be concluded that the time of doing the task can be used to represent the stability. Regarding the vertical reaching task the reliability of the time is more than that of the other parameters. Using time based parameters in functional stability tests is easier than using the force plate; moreover it is not required to use especial facilities, such as force plate and amplifiers. In the research done by Trileo et al which was done on 10 able bodies and 3 individuals with SCI, the reliability of time for vertical reaching task was between 0.44 and 0.96 and for transverse reaching task varied from 0.37 and 0.93 for SCI subjects. For normal subjects it has been reported that the reliability varied between 0.47 and 0.93. the reliability of time based parameter in the current study was more than that of Trilleo etal study, due to different weight used. In contrast in the current study the standard cylindrical weighs have been used.

Although using force plate to evaluate functional stability allows the investigators to collect the data of the COP excursions, it dose not have the reliability as that of the time base parameters, table 3. For other subjects such as SCI patients it is recommended to use other parameters for instance the magnitude of the force applied on the crutches during standing.

There are some limitations regarding this research which is needed to be acknowledged. The sensitivity of the stability parameters was not analysed in this study. Moreover, the number of participants was small. Therefore it is recommended that the sensitivity of the stability parameters, to distinguish between functional stability of various groups of subjects, be measured in another study.

Conclusion

The results of this research showed that the reproducibility of the time based parameters is greater than that of the COP sway based parameters for measuring functional stability. It is recommended that COP sway be used in particular for vertical reaching motions.

Acknowledgment

The author wishes to thank all subjects who kindly participated in this research. This project was supported by a grant devoted to author by Iranian Ministry of health and medical education.

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