Influence of Visual Feedback on Postural Sway in Normal Subjects

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ABSTRACT

The effect of visual feedback on postural sway has been investigated to determine efficacy in reducing postural instability in selected groups. Therefore, 13 males and 16 females were conducted to determine the reliability of the Force Plate in measuring the effects of visual feedback on postural sway. Subjects were evaluated during a period of two days in which four static and eight dynamic trails of postural sway with and without visual feedback were collected in 3 positions (stable, toes, and A/P sway). Results of the data analysis indicated no significant difference between the separate months of testing as well as no significant difference between the gender of subjects in regard to their performance on the tests. Similarly, no significant difference was found between tests with and without visual feedback on all stable and toes trials during the two days of testing. However, during tests of A/P sway, subjects demonstrated significant differences in performance. Despite the variance between the test positions, all subjects demonstrated decreased sway indexes during visual feedback as compared to tests without feedback during all tests. Reliability of the Force Plate was found to be low during the test of stable position and progressively improved rating through other tests. So, further study in this area may prove helpful in establishing normative data to be used as a clinical reference to many different patient populations.

Key Words: *Force Plate: Postural sway: Visual feedback.*

INTRODUCTION

Sensory feedback is a technique that may use visual, auditory, or somatosensory information to facts regarding measurements of a specific interest[3]. Visual feedback, in particular, has been utilized in a number of studies ranging from the slowing of respiration rates to the step length optimization of runners and arm control in Parkinson s patients[6-10,11]. Results of these studies have met with promising statistics, concluding that visual feedback may promote more normal or beneficial behavior.

In recent years, there has been a rise in the number of studies including visual feedback and postural sway in which a variety of investigations including purely static measurement of sway, the combined use of stationary auditory fields with feedback, and experimentation to determine muscles activated with visual feedback during sway have been utilized[1,8,13]. All of these studies have concluded that visual feedback decreases the amount of sway during standing and sway scores are severally marked without feedback. Other studies have attempted to use dynamic measurements of anterior/posterior support surface movements, finding that visual cues

allowed for more rapid correction of body position[9]. Such findings are promising and are important factors for the physical therapist to consider when assessing instability in patients and the associated risk for falls. Several studies in particular have sought to utilize the information of visual feedback during balance training to help population with instability during rehabilitation[2,3].

Shumay-Cook et al,[14] utilized a force plate-feedback system with hemiparetic patients to help establish a more symmetrical posture in standing by way of balance training with visual feedback. Results indicated that post training, lateral displacement of sway was reduced thus giving a more positive response to therapy than had traditional therapeutic techniques been utilized alone. Hamman et al.,[3] also examining balance training with visual feedback, attempted to establish normative data on a computerized system capable of measuring the center of gravity within the limits of stability of the subject. Results indicated that dynamic balance training did not affect static sway scores, however, dynamic scores demonstrated considerably decreased sway post-therapy sessions as compared to pre-therapy measures.

Secondary to these findings, further study in this area is needed to help developing reliability statistic on equipment as well as quantifiable data that the physical therapist may use on any patient population in the clinic. Thus for the purposes of this study, normative data will be collected on the force plate with the hypothesis that there will be no significant difference between subjects in regard to visual feedback and non feedback conditions during measurements of postural sway. Furthermore, statistics will be collected to determine potential variances in sway with and without feedback in regard to gender since a critical review of the literature has revealed a gap in this area of information.

MATERIALS AND METHODS

Subjects

Twenty-nine normal volunteers with normal vision with or without corrective eyewear participated in the study. The subjects mean age was (27 ± 5.61) with 16 females (26 ± 6.34) and 13 males (27 ± 4.77). Subjects were evaluated during a period of two days in which four static and eight dynamic trials of postural sway with and without visual feedback were collected in three positions (stable, toes, and A/P sway). Approximately one month apart subjects were evaluated again using the same procedures.

Instrument of Evaluation

The instrument used for the postural sway evaluation was the force plate, an apparatus equipped with two foot-plates on which four independent vertical force measuring transducers for the ball and heel of each foot are located. During testing, the foot-plates were placed upon a girded, movable platform upon which the sway index-the standard deviation of the time and distance the subjects spend sway for his or her center of balance (point where the ball and heel of each foot has 25% of the body weight) was collected, recorded, and stored at a sampling rate of 100HZ by way of an IBM PC computer. This system is equipped with a computer screen that monitors and displays the subject s center of gravity (COG) within the base of support (BOS) by way a yellow cursor prompt and two red feed respectively. This information may then be utilized as visual feedback by the subject with the aim to correct postural instability and excessive sway[2].

Procedure

Performance of the experiment took place during two consecutive days which measurements of sway were collected in three positions including: Stable, the subject standing normally, unperterbed; toes, in which the platform tilted the subject from toe to heel and then heel to toe; and A/P sway, in which the platform slided anteriorly and then posteriorly. Trails of each position were collected respectively during tests lacking visual feedback and then followed with tests of visual feedback. The protocol was repeated in the same manner during the second day of testing.

Throughout the two days of testing, subjects were instructed to always wear the same footwear throughout the frame of the experiment test dates.

Subjects were placed upon the balance platform in a consistent manner in which feet were placed shoulder length apart, approximating the subjects normal stance width. Next, subjects were placed upon the foot-plates adjusted to the total length of their shoe concurrent with the stance already assumed.

During tests lacking visual feedback, subjects were instructed to look straight ahead with hands to their side. During trials of feedback the computer screen was turned and placed within the visual field of the subject with the instructions given to keep the yellow cursor centered between the two red feet (that represented the base of support) displayed on the screen. Such instructions were given during all tests during the both days of testing.

Data Analysis

Test results of each subject, the sway index score, were retrieved and analyzed for gender difference during the two days of experimentation in the test positions of stable, toes, and A/P sway with a univariate approach to repeated measures of analysis of variance. Intraclass correlation coefficient (ICC) was used to quantify the test-retest reliability between mean postural sway scores with and without visual feedback for all subjects. Multivariate analysis of variance (MANOVA) were used to calculate the reliability coefficients and independent variables. The alpha level for all analysis was set at .05.

RESULTS

Data analysis revealed no significant difference between the separate months of testing with the exception of one test of toes without feedback, $F=2.10$, $p=.045$.

The effect of gender on postural sway and feedback:

The means and standard deviations for the combined measurements of sway and feedback at the two evaluations in regard to gender are listed and displayed in tables (1-3). Repeated measures ANOVA demonstrated to statistical significance among the means: stable ($F=.15$ $p=.930$), toes ($F=.32$ $p=.808$), and A/P Sway ($F=1.10$ $p=.356$).

Table (1): Means and standard deviations for the independent variable: Stable position

	- Feedback				+ Feedback			
	Day One		Day Two		Day One		Day Two	
Subject	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2
Male	.265 (.107)	.234 (.085)	.290 (.099)	.228 (.059)	.205 (.065)	.211 (.084)	.202 (.238)	.218 (.074)
Female	.320 (.113)	.318 (.109)	.300 (.296)	.300 (.171)	.262 (.060)	.239 (.074)	.238 (.092)	.232 (.066)

( ) = standard deviation

Table (2): Means and standard deviations for the independent variable: Toes position

	- Feedback				+ Feedback			
	Day One		Day Two		Day One		Day Two	
Subject	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2
Male	1.245 (.558)	.951 (.251)	.928 (.318)	.885 (.354)	.872 (.501)	.777 (.244)	.634 (.184)	.625 (.191)
Female	1.019 (.252)	.876 (.166)	.947 (.185)	.917 (.216)	.822 (.229)	.769 (.169)	.799 (.145)	.733 (.197)

( ) = standard deviation

Table (3): Means and standard deviations for the independent variable: A/P Sway

	- Feedback				+ Feedback			
	Day One		Day Two		Day One		Day Two	
Subject	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2
Male	1.098 (.258)	.814 (.199)	1.002 (.191)	.898 (.275)	.780 (.182)	.824 (.212)	.786 (.159)	.759 (.128)
Female	1.176 (.306)	1.003 (.308)	1.131 (.220)	.986 (.180)	.977 (.238)	.916 (.231)	.926 (.159)	.859 (.216)

( ) = standard deviation

Reliability

The results of the reliability coefficients from the MANOVA statistics are listed in table 4. The statistics revealed lower scores of reliability during stable conditions and progressively improved ratings through the tests of toes and A/P Sway.

Table (4): ICC Reliability results

Condition	Stable	Toes	A/P Sway
(-) Feedback	.2	.3514	.6667
(+) Feedback	.402	.3333	.75

The effect of feedback on postural sway

The means and standard deviations for the independent variables of test position and feedback are presented in tables (1-3). Means were identified at each separate evaluation and trial for each condition. Multivariate analysis demonstrated no statistical significance in regard to sway with or without feedback for

the means of stable (F=.44 p=.724) and toes (F=1.06 p=.373). However sway indexes were significantly different for the test position of A/P Sway (F=6.63 p=.000).

DISCUSSION

T-test factors for between month variables demonstrated low representation of statistical significance during all trials of the analysis. Therefore the overall factor of month was considered negligible in regard to its role in this experiment.

Alterations in postural sway have been noted in regard to both gender and age.[4,7] Secondary to a limited sample of 29 subjects, age was not assessed as a variable. However, gender differences were evaluated and it was found that no statistical significance was identifiable in regard to test position both with and without feedback.

Kollegeı et al[7] noted during their examination of age in regard to sway, that younger age groups (21-35 years) had no sex-related differences in postural sway. However as subjects were approaching the ages of (51-65), gender differences were highly significant for stable positions in the male population. Furthermore, middle aged men (36-50) exhibited significantly more postural sway than women of the same age group. Juntunen et al,[4] noted comparable results of sway excursion in the sudy of healthy middle aged women and men. Extensive gender studies in regard to visual feedback have not performed, thus leavng a gap in the literature.

Analysis of mean sway scores revealed during both factors of with and without visual feedback, markedly lower excursion of sway during stable tests as compared to those of toes and A/P sway. This may be attributed to the increasing difficulty of tasks from static to dynamic; less effort to maintain and/or correct sway excursion was required to perform stable tests with no outside perturbation. Furthermore, mean sway scores were markedly lower during tests utilizing visual feedback as compared to those without. This can be attributed to the fact that balance is contingent upon three factors, the vestibular, somatosensory, and visual systems. When positive input is increased in one of these areas, balance or body movement may improve. This has been demonstrated in other studies utilizing visual feedback during postural sway; sway scores significantly improved both during static and dynamic tests with the increased input of visual feedback.[1,8,9,13]

MANOVA analysis, while noting statistical significance during only the test A/P sway, revealed during within group variables significance with feedback during all test positions-which again is demonstrated by the markedly lowered mean sway scores during trials with feedback. It should be noted that this may be attributable to a potential learning curve throughout tests.

MANOVA within group factors for trial (the overall groups of tests performed) demonstrated statistical significance only during trials of toes and A/P sway. This again may be related to the increasing difficulty of tasks. In a study by Nichols et al,[12] changes in the mean center of balance (COB) during testing of young adults revealed medial/lateral (COBx) was not affected by position (feet apart, tandem, or together) with or without eyes closed. However, Anterior/posterior (COBy) was affected, with linear tests having the COB move anterior, stable tests exhibiting a posterior COB, and tilt tests with a more neutral center of balance.

While Nichols et al[12] found an increased COB during tilt tests, the variability of the position toes, demonstrated in the within

subject factors of trial, in this study may be attributed to the subject being unprepared for the initial change from static to dynamic tests. Furthermore, when assessing differences between days one and two of testing, scores were somewhat lower during the second day for the toe test, possibly indicating an increased familiarity and expectation of the platform tilt.

The overall significance of the A/P sway test position may be attributed to the COBy as may have been transferred anteriorly secondary to possible increased difficulty in the test procedure. For the purposes of this experiment. It mainly concerned with differences in the mean sway index.

Reliability of the Force Plate was found to be low thoughout all tests. However trials improved as the experiment progressed from the position of stable to that of A/P sway. This may be ascribed to lack of standardized placement of foot-plates between days of testing; subjects were allowed to place feet according to preference. Furthermore, variance may be attributed to inadequate length of time during testing as suggested in a study by Stones et al[15], in regard to discrimination of sway scores of healthy adults. There has been a wide discrepancy upon the belief of specific time frames for testing, with some studies utilizing testing intervals ranging from ten seconds to 20 seconds.[5,12]

The Force Plate test-retest reliability as assessed in the experiment by Dickstein et al[2], indicated stable tests yielded the highest positive correlation in the hemiparetic population. The population of young adults aged (20-24) demonstrated higher reliability during eyes open tests of platform tilt and with the lowest reliability in the linear displacement of the platform. While the population of adults aged (27-50) demonstrated the least reliability during eyes open stable tests and the highest reliability during eyes open tilt tests. Results of this study in regard to the stable condition were similar in that the highest reliability was not yielded during this position. Subjects within the study by Dickstein et al[2] were grouped into differing categories than established in this study; thus possibly attributing to some of the variances demonstrated in the reliability scores.

CONCLUSION AND RECOMMENDATIONS

Despite the variance between the test positions, visual feedback was found to decrease sway indexes as compared to tests without feedback during all tests. Reliability of the force plate was found to be low during the test in the stable position and progressively improved rating through other tests. Secondary to these findings, further study in this area may prove helpful in establishing normative data to be used as a clinical reference to many different patient populations.

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الملخص العربي

تأثير التغذية العائدة بالنظر على التوازن في الأشخاص الأصحاء

يهدف هذا البحث إلى دراسة تأثير التغذية العائدة بالنظر على التوازن لدى الأشخاص الأصحاء وكذلك قياس درجة ثبات الجهاز المستخدم في القياس (قاعدة قياس القوة) وقد شملت هذه الدراسة (٢٩) شخصا من الجنسين ٠ تم تقييم الأشخاص على مدى يومين وأجريت لكل شخص (١٢) محاولة (٤) منها توازن ثابت و (٨) توازن متحرك أثناء الوقوف في ثلاث أوضاع (وضع الوقوف ثابتا ثم الميل إلى الأمام ثم الخلف) ٠ تم تقسيم الأشخاص إلى مجموعتين وكان الفرق بين وقت إجراء التجربة على كل مجموعة شهرين٠ وقد أظهرت النتائج عدم وجود فروقا ذات دلالة إحصائية حينما أجرى البحث في وقتين مختلفين وكذلك عدم وجود فروقا بين الجنسين ٠ كما أظهرت النتائج أيضا أن درجة ثبات الجهاز المستخدم في القياس كانت منخفضة خاصة أثناء الثبات مع زيادة درجة الثبات في الاختبارات الأخرى، وكذلك حدث تحسنا إيجابيا في التوازن باستخدام التغذية العائدة بالنظر بالمقارنة من عدم استخدامها إلا أن الفرق لم يكن ذات دلالة إحصائية عند الثبات ، بينما وجد أن هناك فروقا ذات دلالة إحصائية عند التوازن المتحرك للأمام والخلف ٠ لذا يوصى بإجراء دراسة أخرى في هذا المجال باستخدام أعداد كبيرة ونظام عشوائي لاختيار الاختبارات عند إجراء التجربة حتى يمكن وضع معيار للتوازن يمكن به مقارنة قياسات التوازن في المرضى بالأصحاء وكذلك يوصى باستخدام التغذية العائدة بالنظر لأهميتها في تحسن التوازن .