Physiology

Test-retest reliability of postural stability on two different foam pads

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***Objective*: Foam pads are commonly used devices in the clinics and laboratories to assess postural control. However, no reliability data are presently available to support the use of one type of foam over another. The purpose of this study was to evaluate the test-rest reliability of postural sway parameters while using two different types of foam that are commonly used and to determine which type of foam is optimal for providing a consistent and effective perturbation. *Design*: Test-retest reliability. *Setting*: Clinical setting. *Participants*: Ten healthy young subjects were recruited. *Main outcome Measures*: The Balance Accelerometry Measure device was used to collect postural sway for 90 seconds with eyes open and closed on three different surface conditions (firm, Airex foam and Neurocom foam). Intraclass correlation coefficients were used to determine test-retest reliability. *Results*: Eyes open and eyes closed on a firm surface showed fair to good reliability for the path length value (ICC (3,1) = 0.61-0.64, *p* <0.05). Eyes open and eyes closed on the Airex pad showed fair to excellent reliability for the path length value (ICC (3,1) = 0.41-0.81, *p* >0.05 with eyes open and eyes closed). Eyes open and eyes closed on the Neurocom foam showed fair to good reliability for the path length value (ICC (3,1)= 0.29-0.45, *p* >0.05). *Conclusions*: The Airex and Neurocom foam pads both provide fair to good reliability. The Airex foam had higher reliability scores with eyes closed than the Neurocom foam pad. Both foam pads appear to produce repeatable findings.** *Journal of Nature and Science, 1(2):e43, 2015.*

Foam | Accelerometry | Test-retest reliability | Postural sway | ICC

Human postural control is believed to be modulated based on the integration of different sensory inputs including vision, proprioception, and vestibular feedback.[1, 2] Current theory postulates that there are two different control strategies used to maintain balance that have been described as ankle and hip strategies.[3] Horak and Nashner suggested that the balance system adapts to postural perturbations quickly by combining hip and ankle strategies in different magnitudes and temporal relations.[4] The two different balance strategies are not only present during a postural perturbation, but also coexist during quiet stance in order to help humans maintain static balance.[5, 6]

In an effort to quantify differences in balance performance, quiet stance under different foot positions has been studied to identify balance performance.[7-9] However, standing in different foot positions alone is often still not enough to differentiate between healthy subjects and those with balance deficits.[10] More challenging conditions are required to distinguish between healthy people and persons with balance disorders. Standing on a foam pad provides a convenient method to increase the difficulty of the balance task[11-14] and to allow discrimination between healthy persons and those with balance deficits.[15] Standing on foam changes the sense of body orientation, foot pressure distribution[16] and affects joint receptor and cutaneous mechanoreceptors in the foot.[17] Using different types of foam is believed to increase the difficulty of maintaining balance.[18]

Clinically, foam is also used as a balance training tool to improve balance performance.[19] By increasing the level of difficulty during a balance exercise, balance ability can be improved.[20]. Foam is widely used in both clinical and laboratory settings and studies have demonstrated that foam properties may affect body sway.[16, 18, 21-23] However, there is no reliability data available to support the use of one type of foam over another. The purpose of this study was to evaluate the test-rest reliability of postural sway parameters while using two different types of foam that are used in the clinic and laboratory settings and to determine which type of foam is optimal for providing a consistent and effective perturbation.

Material and methods

Subjects

Ten healthy young volunteers (3M, 7F; mean age 26.9 ± 5.51 years, height 167 ± 8.1 cm) participated in this study. Subjects were consented before their participation in this study which was approved by the Institutional Review Board of the University of Pittsburgh.

Instrumentation

A custom-designed, custom-built accelerometer system was used with a dual-axis accelerometer (ADXL213AE, ± 1.2g, Analog Devices, Inc.).[24] The acceleration data was wirelessly transmitted at 100 Hz via Bluetooth®. The data was filtered using a 4^{th} order, 1.25 Hz low-pass filter, and sway was quantified using peak-to-peak (PtP), root-mean-square (RMS), and normalized path length (NPL) of the acceleration data. The accelerometer was affixed to a gait belt using Velcro. The gait belt was secured around the subjects' pelvis and the senor was attached to the belt so that the axes of the accelerometer were aligned with the anteroposterior and mediolateral axes of each subject. The validity and reliability of the accelerometer and summary measures have been established in a previous study.[24]

Procedure

All subjects were tested twice with 24 to 36 hours between each testing session. Each session consisted of six standing trials: eyes open (EO) and closed (EC) while standing on a solid surface and two different types of foam pads (Blue foam- Airex®: and Gray foam- Neurocom (Table 1). According to the standardized procedure, subjects were instructed to stand barefoot with feet together and arms crossed in front of the chest and as still as possible for each 90 second trial. The order of testing was presented to each subject as follows: 1) EO on solid surface; 2) EC on solid surface; 3) EO on blue foam; 4) EC on blue foam; 5) EO on gray foam; and 6) EC on gray foam. A one minute rest was required between conditions to avoid fatigue. A successful trial was recorded as a subject maintaining the testing stance for the entire 90 second trial. After successfully completing the 90 second trial, the next stance condition was tested. If the subject could not maintain the stance position for 90 seconds (took a step, moved

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Table 1. The blue and grey foam properties.

	Dimensions (cm)	Density (kg/cm^3)	Tensile strength (kPa)	Elongation to Break (%)	Material
Blue Foam	50.0 x 41.0 x 6.0	55	260	180	firm
Gray Foam	45.7 x 45.7 x 12.7	60	172.4	200	soft

Table 2. Foam test-retest reliability - ICC with two way mixed consistency model.

Visual Condition	Surface Condition	Sway Parameter		
		Peak to Peak	RMS	Path Length
EO	Firm Surface	0.64*	0.59*	0.64*
EC	Firm Surface	0.66*	0.57*	0.61*
EO	Blue Foam	0.18	0	0.41
EC	Blue Foam	0.01	0.34	0.81*
EO	Gray Foam	0.20	0.12	0.45
EC	Gray Foam	0.44	0.02	0.29

* Significant p < 0.05; EO: eyes open; EC: eyes closed; RMS: root-mean-squared.

their arms, or opened their eyes), the trial would be marked as a fall trial and would be repeated. Three attempts were permitted for each condition. The condition would be marked as a failed condition after three attempts and the subject was asked to perform the next stance condition.

Statistical analysis

In order to assess test-retest reliability of the measures, the two way fixed consistency model was used to determine the hypothesis test for equivalence, the intraclass correlation coefficients (ICC (3,1)). Excellent reliability has been suggested with ICCs ranging from 1.00 to 0.75, fair to good from 0.40 to 0.74 and poor from 0.4 to 0.[25] Descriptive statistics of performance (mean ± SD) were calculated across the two testing sessions for each sway parameter within each test condition. The Friedman test was used to compare the mean differences of postural sway parameters under EC and EO conditions. Post hoc analysis with Wilcoxon signed ranks test was conducted with a Bonferroni correction (p = 0.05/3=0.017) applied.

Results

Reliability of measures

The reliability of all 6 conditions ranged from excellent to poor (Table 2). Eyes open and eyes closed on a firm surface showed fair to good reliability (ICC(3,1) = 0.57-0.64, p <0.05). Eyes open and eyes closed on the blue foam showed fair reliability for the peak to peak value and RMS values (ICC(3,1) = 0-0.34, all p >0.05), and fair to excellent for the path length value (ICC(3,1) = 0.41-0.81, p >0.05 with eyes open and p <0.05 with eyes closed). Eyes open and eyes closed on the gray foam showed poor to good reliability(ICC(3,1)= 0.02-0.45, p >0.05); however standing on the gray foam did not show any significance in the hypothesis test for equivalent (ICC(3,1) = 0.2~0.45, all p > 0.05). All the subjects completed all the six conditions without falling.

Sway parameters

The Friedman test indicated significant differences among the three surfaces under eyes open and eyes closed conditions in the three parameters. Post-hoc analyses are illustrated in Figures 1 to 3. Standing on the blue foam showed significantly higher values than firm surface under eyes open and eyes closed conditions in the three parameters. Standing on the gray foam showed significantly higher values than firm surface only under EC conditions in RMS and eyes open and eyes closed conditions in NPL. There were no significant differences between the blue foam and the gray foam for any condition and on any parameter.

Discussion

Our purpose of this study was to investigate postural sway reliability while using foam as a tool to increase postural sway. Our data suggested that postural sway increased when subjects stood on foam. There was no significant different between the two types of foam. However, the NPL for the blue foam was more reliable than the gray foam.

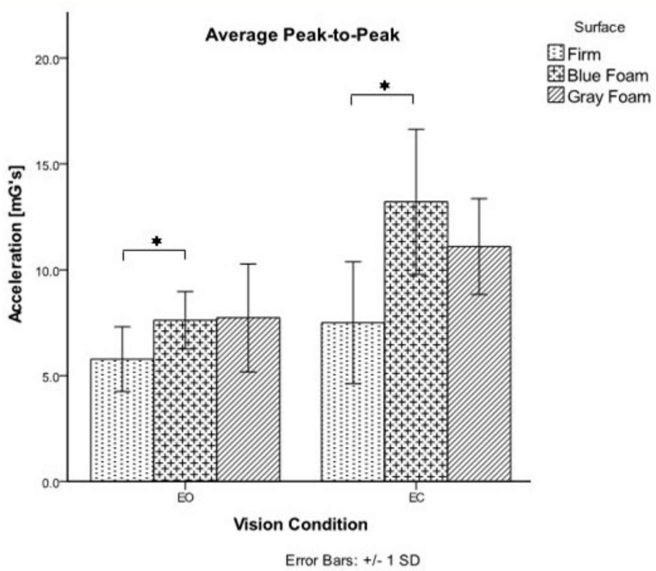

Figure 1. Across subject mean peak-to-peak (PtP) sway measures for six conditions (error bars represent ± 1 standard deviation). The blue foam PtP means were significantly higher than the PtP on the solid surface in both the eyes open and eyes closed conditions (p < 0.017); mG's: milli-Gravitational accelerations.

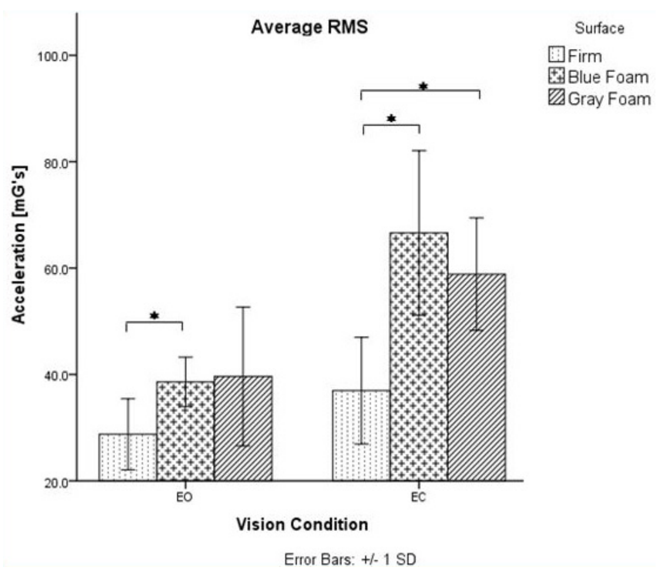

Figure 2. Across subject mean root-mean-squared (RMS) sway measures for six conditions (error bars represent ± 1 standard deviation). Post hoc significant differences were found between firm and blue foam in the eyes open condition and between firm and blue foam and firm and gray foam in the EC conditions (p < 0.017); mG's: milli-Gravitational accelerations.

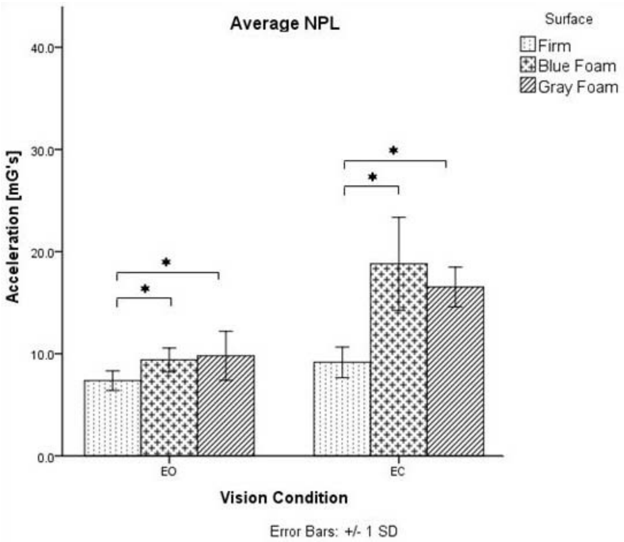

Figure 3. Across subject mean normalized path length (NPL) sway measures for six conditions (error bars represent ± 1 standard deviation). Post hoc significant differences were found between firm and the blue foam and firm and the gray foam in the eyes open and eyes closed conditions ($p < 0.017$); mG's: milli-Gravitational accelerations.

Using accelerometry measures for postural sway has demonstrated good reliability and validity.[24] Among those postural sway parameters, NPL showed excellent test-rest reliability and sensitivity to detect postural sway change during accelerometry measures.[24] The reliability of the NPL measure appears to be fair to excellent on the blue foam and fair to good on the gray foam. The enhanced reliability and significance of hypothesis test for equivalence under the eyes closed condition demonstrates that the NPL parameter was more sensitive compared to PtP and RMS under the same conditions.

The ICC may have been affected by the small between subject variance.[26] The between subject variation is small on the gray foam (Table 3). The small variance while standing on the gray foam might due to greater compression of the gray foam when a subject stood on it. It is possible that subjects may be able to partly sense the hard surface beneath the foam because of the greater compression of the gray foam. The gray foam may have provided more accurate feedback from the hard surface and decreased their postural instability compared to standing on the blue foam under eye open and closed conditions.

There was not any significant difference among the postural sway parameters between the blue and gray foam. Patel *et al.* has suggested that foam density and elastic modulus are correlated to postural instability.[18] They concluded that the higher foam density and elastic modulus, the higher the postural instability.[18] Although the elastic modulus of the two foam pads is not available, the foam material with blue foam implies higher elastic modulus than the gray foam. The blue foam has lower density but higher elastic modulus and the gray foam has higher density but lower elastic modulus. However, the NPL of the blue foam under the EC condition showed a significant result during the hypothesis test for equivalence. It may imply that the blue foam provides a more reliable measure.

The two types of foam pads tested are commonly used in clinics. Carbin et al. [23] had suggested that the texture of foam may affect postural sway. Our results may suggest that foam pads of different textures provide different sensory input. Although how the different textures of foam pads influence postural sway is not clear, a goal of balance training is to improve one's balance ability under different conditions. Using different textures of foam can increase the variability of balance training conditions.

Limitations of this study are the small number of subjects. With small numbers of subjects, the ICC may have been affected by less between subject variance. Further study should increase the subject numbers with different age groups.

Conclusion

The blue and gray foam pads both provide fair to good reliability. The blue foam had higher reliability scores with eyes closed than the gray foam pad. Both foam pads appear to produce repeatable findings.

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Biographies

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