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INTRODUCTION

Balance makes many daily tasks possible, from walking to more advanced movements associated with sports and agility. Having efficient balance prevents injuries and promotes an active, healthy lifestyle. It has been shown that greater balance scores have been associated with greater sport performance, which makes a seemingly trivial aspect of performance more important than one would think (Hrysomallis, 2011). With balance being a necessary element to daily living, many studies address balance testing and factors influencing balance as it relates to prevention of injuries. McGuine and Keene (2006) proposed a balance training program to reduce the risk of common injuries in high school athletes. This study evaluated the need for balance in young populations to reduce the risk of injury as well as with aging populations and found that injury frequency was lower when a balance training program was administered (McGuine & Keene, 2006). As performing physical activity is important for many ages, improving the individual's balance can also improve performance as well as daily living function.

Balance is commonly tested with a variety of balance tests based on the norms for different ages. A test often utilized for assessing dynamic balance is the Y-balance test (YBT), which requires strength, flexibility, neuromuscular control, stability, range of movement, balance and proprioception. Gonell et al. (2015) states that this test can be performed on a variety of surfaces, which calls into question whether or not surface textures could influence balance scores. The YBT test was found to have high reliability in the Gonell et al. study, making it a useful dynamic balance test. Kinzey and Armstrong (1998) found the modified star excursion test, which is similar to the YBT, to be reliable in a clinical setting and has been used with apparently healthy 18-35 year old populations. Balance issues are more common in clinical settings such as rehabilitation clinics for aging populations. Liston and Brouwer (1996) studied the balance master board and found it to be a reliable and valid equipment when measuring dynamic movements associated with functional balance, specifically in stroke victims. The balance master offers a bit of variety as well as entertainment to the participants. In the Fitzgerald, Smith, and Caulfield study (2010), it was shown that those who participated in "game-like activities" achieved higher balance scores. Using a Neurocom Balance Master, the game-like activities within the balance tests serve as entertainment motivating the participant to perform the balance test to the participant's full potential. With the increased motivation along with the different surface types, we expect balance scores to be affected by the tests and by the conditions the participants are under. It was imperative that the balance tests were done barefooted because shoes significantly decrease sway in stance (Smith et al., 2015). A closed-chain barefoot assessment reveals the participant's natural foot positioning and will be useful when comparing results. These two types of equipment and balance tests are reliable in the populations they were studied in, but we believe that our research will begin filling up the age and health status gaps. While balance tests can educate on the balance status in individuals, there are also physiological factors that influence balance.

Factors that most commonly affect balance are vision, somatosensation, and the vestibular system. The input from your eyes will notify you of movements in the surrounding environment, which may make balance more difficult. Somatosensation refers to the proprioception or the input gained from the soles of the feet and joints that allows for an assessment of the surface that is being stood on. Lee and Aronson (1974) showed the importance of visual proprioception, by studying a group from the infant population and how visual proprioception has a dominant role in maintaining posture relating to balance. They stated that visual proprioception is equally important as mechanical proprioception, especially as humans grow older. This article focused on infantile populations but seeing this importance in infant growth relates back to the need for these physiological characteristics throughout the growth process. Regarding mechanical proprioception, Hatton et al. (2011) reported that more textured surfaces allow for greater balance improvements as compared to smooth surfaces. In this research, it was hypothesized that a surface that increases mechanical proprioception could improve balance scores. An example of a textured surface is the NABOSO (meaning "barefoot" in Czech). The NABOSO mat, according to the official site of this product, is designed to enhance and activate the proprioceptors of the bottom of the feet and the palms of the hands (Better Barefoot Movement, n.d.) and enhance balance improvements. The site also mentions that previous studies have shown that traditional yoga mats block the proprioceptors of the feet and hands. As a result, stability, balance, and performance will be decreased. The vestibular system is the third factor that may affect balance. It is the input received from the inner ear that allows an assessment to be made about a turning/rotating environment. Each of these components play a factor in the effects of balance in individuals of all ages and populations.

Populations that are utilized in balance research are generally geriatric individuals or patients with a diagnosis that affects balance (Barnett et al., 2003, Liston & Brouwer, 1996, McMichael et al., 2008). There are limited studies that investigate the factors that influence the balance of younger populations. In relation, the Gonell et al. (2015) study was performed on younger populations and concluded that the YBT is useful with assessing balance and detecting injury, and also spurring on additional research that is needed to see whether surfaces differ in YBT scores in younger populations. Another common trend in previous balance-related research is that many balance-test investigations are performed on a standard surface such as a hardwood floor or regular yoga mat surfaces. The Hatton et al. study (2011) suggests that a modified surface can increase proprioception and balance. It remains inconclusive as to how a modified surface mat can be relevant for older and special populations in clinical settings, as well as younger populations in everyday settings. To date, there are scant research studies that include balance tests on a textured surface such as the NABOSO mat or that determine if there is an effect on balance test scores depending on the surface texture. The purpose of this study was to observe whether there is a difference in balance scores when utilizing different floor surfaces. The surfaces used to assess the balance scores were hardwood, traditional yoga mat, and NABOSO mat. It was hypothesized that the utilization of a NABOSO mat would elicit an increase in balance scores and decreased sway scores as compared to the remaining surface conditions.

MATERIALS AND METHODS

Overview of the study: This study was conducted on a group of 18 Georgia College students between the ages of 19-25 years. They completed a standardized warm up and were assessed through a closed-chain barefoot assessment. These individuals were randomly assigned to a pattern (order) of surfaces for the completion of the two tests. In total, there were six different pattern possibilities. The participants went through the pattern of surfaces first on the Neurocom Balance Master and second on the Functional Movement Systems Y-Balance kit.

Participants: Investigators recruited 18 participants to complete this study, through advertisements posted at approved locations. Subjects, aged 19-25 years who were interested in this project contacted the investigators via email. Interested individuals were sent via email the Physical Activity Readiness Questionnaire (PARQ +) for Everyone, which is a survey that assesses the individual's ability to participate in exercise (Warburton et al., 2011). It identified any factors that would prevent individuals from being eligible to safely participate in this study. Individuals were excluded if they had previous acute lower body injury, vestibular issues, and/or on medications that caused dizziness. Individuals who indicated that they had any of these issues, as indicated on the PAR Q+, were thanked for their interest, but excluded from the study. Eligible individuals were invited to participate in the study and scheduled for their private appointment. Participants in the study were asked to arrive to the testing laboratory in loose, comfortable clothing and having abstained from alcohol consumption and strenuous physical activity for at least 24 hours prior to their appointment.

Data Collection: Upon arrival, participants' signatures were obtained on the PAR Q+ document. They were asked to fill out two informed consent documents, one for them to keep and one for the investigators to have as documentation. After they filled the informed consent, the individuals were asked to take off their shoes and socks for the remainder of the assessments. Participants then completed a barefoot assessment. The barefoot assessment entailed the individual finding a natural footing; the investigators then assessed their foot position from frontal, transverse and sagittal plane as well as their weight distribution (Nawoczenski, 1998). After the barefoot assessment was completed, the height of the participant was measured and used later for the Neurocom balance master assessments. Their leg length was also measured from the anterior superior iliac spine to medial malleolus of the dominant leg to use on the Y-Balance test calculations. Participants then completed a standardized warm up that consisted of 3-5 minutes of movements intended for loosening the joints and increasing range of motion and blood flow. This entailed dynamic leg swings of 20 repetitions on each leg, and side to side leg swings of 20 repetitions on each leg. Next, the subject performed ankle range of motion movements of 10 in each direction for both legs. Lastly, the warm up concluded with toe stretching, which consisted of gripping and flexing the toes 10 times on each foot.All participants were randomly assigned as to how they would progress through the floor surface conditions they would complete on the Neurocom balance master and the FMS Y-Balance test. Participants began the battery of balance assessments by completing the Neurocom Balance Master tests and then the Y Balance test. They would follow the floor surface condition progression randomly assigned to them. After subjects completed all balance assessments on the first condition, they switched to the second condition and completed the same set of balance assessments before switching to the third condition. Mats were sanitized with Lysol wipes between each participant use to decrease the risk of bacterial infections.

Participants performed the Unilateral Stance test using the Neurocom Balance Master. The procedures for the test were as follows: the participant's feet were aligned to marked portions of the balance master board. The setup was then copied onto the two other floor surface types. The subject first balanced on their right foot, both with their eyes open and eyes closed, completing three trials. Subjects then completed the same procedures on their left foot, completing three trials with their eyes open and closed. Participants were instructed to keep their hands on their hips and to make sure their legs did not touch during the test (Liston & Brouwer, 1996). Participants were given 15 seconds of rest in between trials and 60 seconds of rest in between tests.

Participants were given another 60 seconds rest before performing the remaining balance assessment. The Y Balance test, which tests dynamic stability, was performed on both legs. A practice round followed by three trials took place. One leg was stationary and served as their base of support, while the other leg reached in three different directions (anterior, posteromedial, and posterolateral) on the Functional Movement Screen (FMS) Y Balance test kit. Individuals completed this test on the dominant leg first, and then on the non-dominant leg. After each trial, the individuals were given a break of 15 seconds in which they were allowed to stretch their ankles and legs. The participants were instructed to gently move the box with their toe and bring the foot back to standing position on the ground, next to the foot that was being tested, in a slow and controlled movement. The participant had to start the trial over if he or she slid the box out further than toe could reach or if they lost balance. The investigators made note of the furthest point their toe moved the box. Participants completed each foot in all three directions, three times each. A rest break of 60 seconds was provided between legs. After the test was administered, the test scores were determined by taking the highest distance in each direction in centimeters. The relative distance on each leg was calculated (in percentage) for each participant, taking into consideration their leg length ([sum distance in each direction/ 3 x leg length]x100). The composite score was calculated by taking the average of each leg in each direction, these scores were added together and divided by (3 x the leg length in centimeters) x 100 (Fullam et al., 2014).

After all individuals completed all tests in all three conditions, the investigators thanked the participants for their time and dismissed them. Upon request, an individual feedback report was sent to participants, including ways for them to improve their balance.

Statistical Analysis: Descriptive statistics (M±SD) were obtained for all dependent variables. A repeated measure analysis of variance test (RM ANOVA) was used to compare the balance test scores among the three surface test conditions (control, yoga mat, NABOSO mat). If the RM ANOVA produced statistically significant findings, a post hoc analysis was implemented to determine which conditions were significantly different from one another. Statistical significance was set at $p<0.05$. All data collected were analyzed using SPSS (Statistical Package for the Social Sciences) Version 22.

RESULTS

This study consisted of 18 college-aged participants ranging from ages 19-25. Each student expressed interest in this study and none were ineligible to participate due to exclusion factors. The 18 participants were randomly assigned to a pattern of test conditions to complete the tests as previously described. All 18 participants completed the study and were used for data analysis.

A repeated measures ANOVA test revealed that there were no significant differences found among the three floor surfaces for neither the Neurocom Balance Master Unilateral Stance test nor the Functional Movement Screening Y Balance test ($p>0.05$).

Figure 1 provides a visual representation of the results of the Neurocom Balance Master Unilateral Stance Eyes Open test. The results represent the mean and standard deviation of postural sway measured in degrees per second on left and right foot. Left foot on control surface measured 0.85 ± 2.77 degrees per second (mean ± SD). Right foot on control surface measured 0.65 ± 0.34 degrees per second (mean ± SD). Left foot on yoga mat surface measured 0.82 ± 0.29 degrees per second (mean ± SD). Right foot on yoga mat surface measured 0.61 ± 0.20 degrees per second (mean ± SD). Left foot on NABOSO mat surface measured 0.89 ± 0.50 degrees per second (mean ± SD). Right foot on NABOSO mat surface measured 0.76 ± 0.52 degrees per second (mean ± SD).

Figure 2 shows the results of the Neurocom Balance Master Unilateral Stance Eyes Closed test, and represents the mean and standard deviation differences between left and right postural sway values measured in degrees per second. Left foot on control surface measured 1.90 ± 0.61 degrees per second (mean ±SD). Right foot on control surface measured 1.82 ± .81 degrees per second (mean ± SD). Left foot on yoga mat surface measured 1.8 ± .66 degrees per second (mean ± SD). Right foot on yoga mat surface measured 1.74 ± 0.65 degrees per second (mean ± SD). Left foot on NABOSO mat surface measured 1.97 ± 0.79 degrees per second (mean ± SD). Right foot on NABOSO mat surface measured 1.76 ± 0.79 degrees per second (mean ± SD).

Figure 3 represents the Y Balance test composite results measured in percentage of scores in centimeters/3 x leg length based on individuals personal leg length. As indicated the scores between conditions show no significant difference between conditions tested. The Y Balance Composite score for the control condition was 99.03 ± 5.77 measured in percentage based on leg length (mean ± SD). The Y-Balance Composite score for the yoga mat condition was 99.11 ± 7.28 measured in percentage based on leg length (mean ± SD). The Y Balance Composite score for the NABOSO mat condition was 99.05 ± 6.55 measured in percentage based on leg length (mean ± SD).

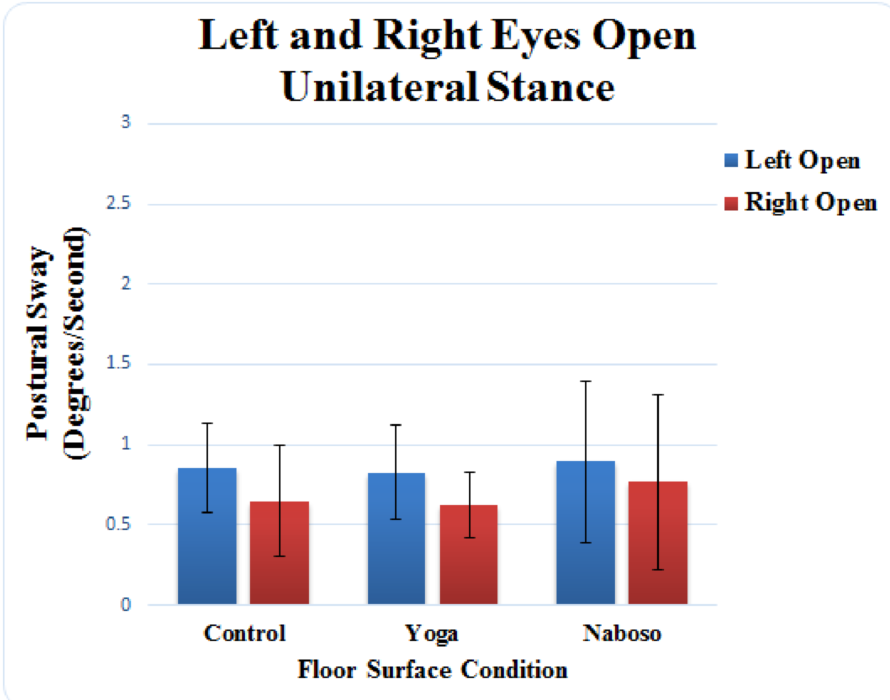

Figure 1: Left/Right Eyes Open Unilateral Stance Test on Neurocom Balance Master results represent postural sway measured in degrees/second.

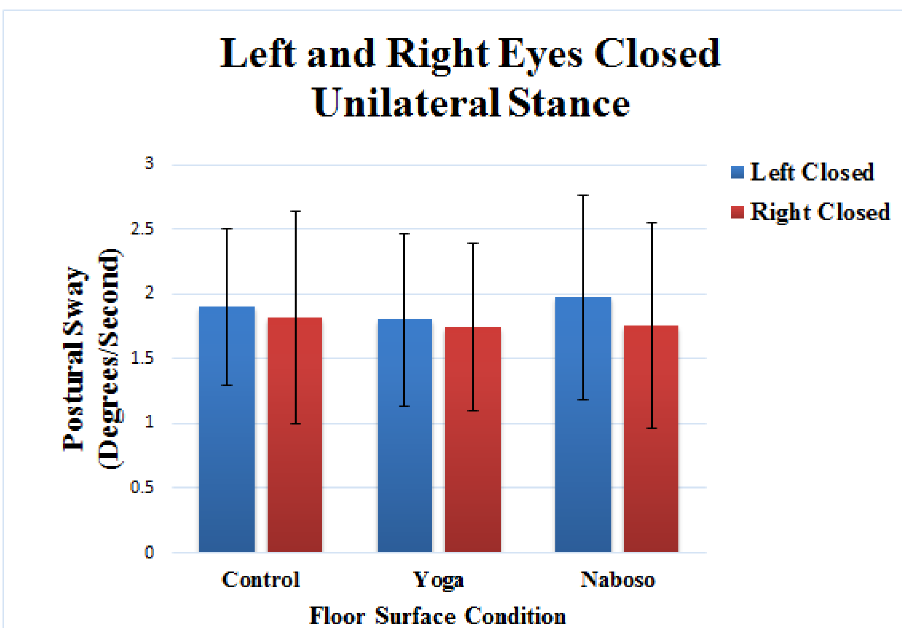

Figure 2: Left/Right Eyes Closed Unilateral Stance Test on Neurocom Balance Master results represent postural sway measured in degrees/second.

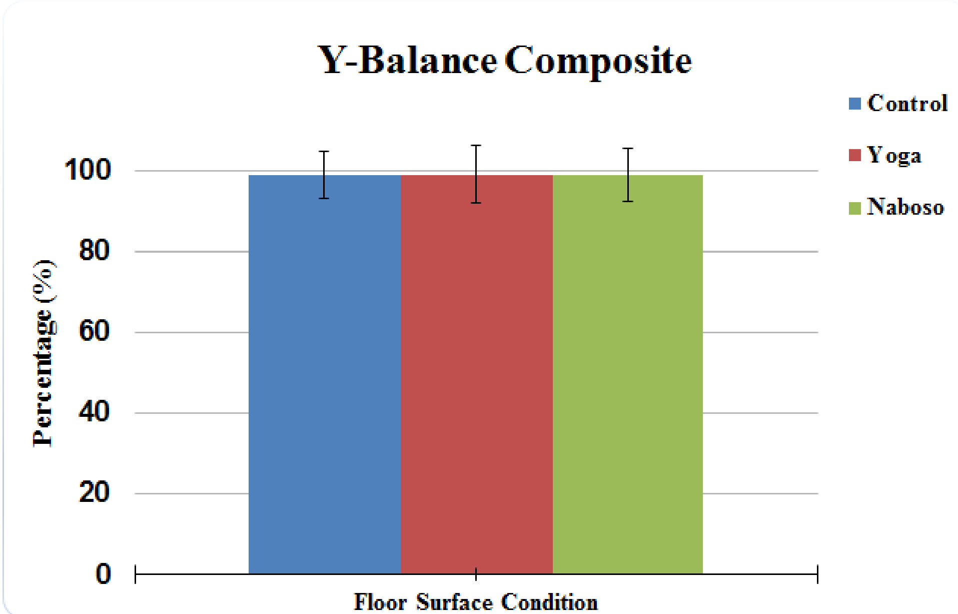

Figure 3: Y Balance Composite Score on all three conditions; results represent percentage (%) scores based on participants individual leg length (Anterior+Posteromedial+Posterolateral score / 3 x leg length).

DISCUSSION

The aim of this study was to examine whether surface types affect balance scores in healthy college-aged individuals. The researchers further examined the differences of surface types with static and dynamic tests of balance. The results showed that there was no significance between surface types and balance scores. The statistical significance was set at $p=0.05$ and none of the data results were smaller than this number. The findings led to the notion that because there was no statistical evidence supporting the NABOSO mat having a positive effect on balance, the investigators failed to reject the null hypothesis. Because the researchers failed to reject the null, there was not a significant difference in balance performance across the three different floor surfaces.

The results presented in Figure 1, Figure 2 and Figure 3 are different results than what was expected for this age group and population. With the rise of popularity in barefoot training, it was expected the NABOSO mat would increase proprioception and therefore increase balance, but our results did not find this effect. Hatton et al. (2011) stated in their background that previous studies found inconclusive evidence that textured surfaces could be used in intervention programs for older adults and improving balance. Their study explored surfaces on double-limb balance in older adults, and the results showed statistical significance between one surface texture and control surface in mediolateral sway. The texture 1 (Evalite Pyramid) showed less mediolateral sway than the control surface (flat surface) (Hatton et al., 2011). There were inconclusive results seen in past studies of older populations, but we expected to see a result in apparently healthy college-aged individuals. Without this expected effect, it was believed that it would be seen in the data results. Further research must be conducted to conclude the effectiveness of the NABOSO technology. Since individuals spent less than one hour around and on this surface type during our study, a limitation could be deduced that there was not enough time for individuals to benefit from this surface type and the mechanical proprioception it says it produces. With more exposure to the surface, increased proprioception and increased balance could occur with time and training. Fitzgerald et al. (2010) found significant improvement in dynamic balance after 12 exercise sessions on the wobble board surface. This effect was seen in a population similar to ours with 22 apparently healthy adults (Fitzgerald et al., 2010). There could be more substantial results seen in barefoot trainers that spend more time consciously training for increased balance on this surface rather than just completing two balance tests on this surface condition.

The results of our study did not indicate that surface conditions had any influence on balance scores; this may be because of limitations in the research process. A limitation presented in this study was the lack of familiarization of the tests, especially on the Y balance test. The participants were subjected to one to two practice trials per test, which would not be sufficient time for the individual to adapt to the movements. Although not complex, the movements are not frequently used in daily life activities. Gonell et al. (2015) used the Y balance test to assess risk of soft tissue injury. They allowed soccer players being studied to practice six trials before completing formal testing to allow for familiarization (Gonell et al., 2015). This is important because this study also utilized randomization and familiarization in order to improve the accuracy of data results. Another limitation present during our study was the utilization of the small sample size (18), as well as the amount of tests that were performed and data collected in one time frame of approximately an hour and a half. Hatton et al. (2011) recruited 50 participants and found statistical significance in favor of textured surface and sway. Fitzgerald et al. (2010) recruited 22 participants and found a statistical significance in effect of wobble board on dynamic balance (Fitzgerald et al., 2010; Hatton et al., 2011). The researchers believed that the wobble board in the Fitzgerald study was similar to the Neurocom balance master due to the game-like activities utilized in both research studies.

The fatigue from the amount of tests each participant performed in a relatively small period of time could have contributed to a greater variability in the results from one test to the other and, also, the transition from one condition to the other. The investigators hoped to reduce the fatigue factor with the randomization of the conditions and performing the first couple of tests that caused the least amount of physical exertion. But with the Y balance test performed after all of the tests in the Neurocom Balance Test, the Y balance tests could have been progressively performed worse after each trial and condition. To prevent this from occurring, frequent and self-imposed breaks by the participants were set into place if needed. There was a chance that more accurate and precise results could have been achieved if the data collection was split into two days, assessing the participant on Neurocom Balance Master in one day and then the Y Balance Test on another day. The fatigue factor was not accounted for as a large influence of research study results. However, due to the limited amount of time required for collecting data, the investigators decided to collect the participant's data in one day.

Future studies should consider splitting up the Y balance test and the Neurocom Balance Master test in two separate days instead of having all data collection per participant occur on one day. This could possibly rule out fatigue that the participants may be incurring. Also increasing the sample size would help to more accurately observe whether the NABOSO mat has an increasing effect on balance and proprioception or experiences similar results to this study. The researchers of this study recommend that a new sample population for future studies could consist of only college athletes since, during their training, they might be exposed to movements that are similar to the ones that were done in the study, and can determine if mat surface plays a factor in their balancing ability and proprioceptive function. Although this research did not find statistically significant differences among the conditions presented, there are many aspects of this study that can be utilized further in this research field. Further investigation is required to take into consideration the limitations presented to provide more clinically useful evidence in surface textures and their effect on static and dynamic balance.

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