BALANCE TRAINING ALTERS POSTURAL DYNAMICS UNIQUELY FOR STANCE ON COMPLIANT VS. NON-COMPLIANT SURFACES

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INTRODUCTON: Balance training is a common clinical modality used for improving postural control and preventing injury during sports training and participation. However, a number of empirical studies have failed to support the efficacy of balance training. One factor that may have limited the previous empirical studies is a lack of sensitivity with regard to the traditional descriptive statistics used to characterize postural control. Recent developments in non-linear dynamic analyses have led researchers to revaluate the way in which postural control is measured and understood. The advantage of nonlinear analyses for assessing postural behavior is their sensitivity to changes in the time-dependent structures of continuous postural sway. Lyapunov Exponent (*LyE*) is defined as the slope of the average logarithmic divergence of neighboring trajectories in a state space (Wolf, 1985). The purpose of this study was to evaluate the effects of balance training on postural control in a healthy population using both a traditional (position variability; as measured by standard deviation) and non-linear (Lyapunov Exponent; LyE) measure of postural sway variability.

METHOD: Twenty six healthy college-aged participants completed a six-week balance training program. The program consisted of seven balance exercise performed three times a week under the supervision of the research staff. Throughout the training period, each exercise was increased in difficulty according to the participant's willingness to proceed to more advanced levels of the exercise in concurrence with evaluation of an Athletic Trainer. This was done to mimic current physical fitness and rehabilitation training methods, as well as to ensure that each participant's postural stability remained challenged throughout the duration of the program.
Prior to and immediately following the training program, postural sway was observed by recording each participant's COP via in ground forceplate during upright bipedal stance performed on both hard and foam surfaces. Each stance trial lasted 30-sec and the COP collection rate was 100 Hz. COP *LyE* was derived using Chaos Data Analyzer (CDA) software (Sprott & Rowlands, 1992) for anterior-posterior (A-P) and medial lateral (M-L) planes independently (D=6, N=1, A=10^4). In addition, researchers also computed COP position variability, defined as the standard deviation of the entire A-P and M-L COP trajectory of each stance trial.
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RESULTS: For the M-L LyE the analysis revealed a main effect of condition (increase local stability on foam surface), $p < .000$, and no effect of phase, $p = .543$, but a condition*phase interaction, $p = .006$. Simple comparisons showed that participants exhibited increased M-L *LyE* following balance training for stance performed on the hard surface ($p = .037$), but decrease M-L *LyE* in stance performed on the foam surface ($p = .007$). For the A-P LyE the analysis showed no effect of condition, $p < .314$, and no effect of phase, $p = .484$, but a condition*phase interaction, $p = .042$. Simple comparisons showed that participants did not exhibit increased A-P *LyE* following

balance training for stance on the hard surface (*p* = .116), but did exhibit decreased A-P *LyE* in stance on the foam surface (p =.039). For the M-L COP SD the analysis revealed a main effect of condition, p < .000 (increased variability on the foam surface), no effect of phase, p = .235, and no condition*phase interaction, p = .120. Simple comparisons showed that participants exhibited no effects of training in M-L COP *SD* on the hard (p = .09) or foam (p = .415) surfaces. For the A-P COP SD The analysis revealed a main effect of condition, p < .000 (increased variability on the foam surface), no effect of phase, p = .235, and a condition*phase interaction, p = .006. Simple comparisons showed that participants exhibited no effects of training on A-P COP *SD* on the hard (p = .09) surface, but an increase on the foam (p = .002) surface.

DISCUSSION: In general, the results indicate that balance training causes a decrease in local dynamic stability (as assessed via COP *LyE*) for stance on a hard surface, but an increase in dynamic stability for stance on a foam surface. A preliminary interpretation is that inherent constraints of each surfaces requires different movement dynamics in order to promote successful upright posture that are learned during balance training. In addition, results of position variability were not generally sensitive to the effects of balance training, except for an increase in A-P position variability following training on the foam surface. Again, interpretation of this finding is that an increase in the average area of the COP trajectory might be an appropriate strategy for postural control on a compliant surface.

REFERENCES:

Sprott, J.C. and Rowlands, G. (1992). Chaos Data Analyzer: The Professional Version. American Institute of Physics, USA.

Wolf, A., Swift, J.B., Swinney, H.L., & Vastano, J.A. (1985). Determining Lyapunov exponents from a time series. *Physical D*, 16:285-317.