EFFECTS OF 6 WKS OF YOGA TRAINING ON SELECTED MEASURES OF STATIC AND DYNAMIC BALANCE

Tobin Silver and Monique Butcher Mokha
Barry University, Miami Shores, FL, USA

The purpose of this study was to measure the effects of 6 wks (2 x/wk) of Hatha yoga training on selected measures of static and dynamic balance. Initially, 30 adult, healthy males and females volunteered for this study. At 6 wks, n_{yoga} = 6, $n_{control}$ = 7. All participants underwent one static and two dynamic tests on a force plate prior to and 6 wks into the study. SD of the COP in the x and in the y directions were averaged for each test and compared between groups and across time using mixed model ANOVAs. The only significant difference was the main effect for time on A/P leg swing (dynamic balance) in the x direction. Mean differences were observed for the yoga group in both dynamic balance tests in the x direction. We suggest a training stimulus of 2 sessions/wk and/or 6 wks of yoga is not adequate to significantly influence static and dynamic balance.

KEY WORDS: yoga, static balance, dynamic balance, COP

INTRODUCTION: Yoga is an ancient discipline that has recently been adopted by the Western society. The practice of yoga has even been placed in the alternative medical category because of its ability to heal the body as a whole. Yoga is now being used by many athletic teams to prevent musculoskeletal injuries (Raub, 2002). Most athletic events that incorporate stretching usually use yoga asanas and refer to them as stretches (Bera & Rajapurkar, 1993). An asana is a position of the body and is held for a length of time while the participant concentrates on the breath. Asanas are one of the many components that comprise the practice of yoga. Scientific investigations published on the physical benefits of yoga are limited. Bera and Rajapukar (1993) examined body composition, cardiovascular endurance, and anaerobic power as a result of yoga sessions held 45 minutes a day, 3 days a week for 1 year. The training consisted of asanas, pranayama, (breathing) bandhas, (locks) mudras, (seals) and sodhana kriyas (energy movement). Results showed a significant improvement in body density, ideal body weight, cardiovascular endurance, and anaerobic power. Tran, Holly, Lashbrook, and Amsterdam (2001) measured ten healthy untrained volunteer's muscular strength and flexibility after yoga training for 85 minutes, 4 times per week for 8 weeks. Results showed significant increases in muscular strength and flexibility. Others have found improvements in hip and truck flexibility (Ray, et al., 2001) after yoga training. While these studies begin to quantify some of the physical benefits of performing yoga, none have included any measures of balance.

Tai Chi is a practice that places the body in positions that challenge balance, just as yoga does. Thorton, Sykes, and Tang (2004) measured balance using the functional reach test of 17 women; participating in Tai Chi for 60 minute, 3 times per week for 12 weeks. Their findings showed Tai Chi improves static balance by increasing the functional reach in participants. It is possible that yoga would have similar effects.

Poor balance inhibits a person's ability to perform activities such as walking, running, jumping, and throwing. Lan, Lai, & Chen (2002) found practitioners of Tai Chi Chuan to have better balance than non-practitioners. They concluded that the results could be due to repeatedly practiced single leg standing in different postures; indicating that balance improvements may be attainable with practice. The body acts as an inverted pendulum with its center of gravity (COG) rotating around the center of pressure (COP). As the COG moves in front of the COP the ankle is plantar flexed causing a reversal of rotation (Winter, 1990). Thus, quantifying changes in these measures would provide insight into training effects on balance. However, functional tests exist that are used by coaches, athletic trainers, and physiotherapists to measure balance in athletes and patients. Some examples of these tests include the Balance Sub-scale of the Mobility Index, the Berg Balance Scale, and the Timed Up-and-Go Test. These tests are administered with relative ease, low cost, and in a minimal amount of time. However, they often are influenced by the reliability of the examiner, and may lack the sensitivity to detect minute changes in balance. Laboratory tests may cost more and involve examiner training to use the equipment, but they are more accurate. Some laboratory tests include the Limits of Stability Test (LOS), use of the Biodex™ Balance System, and use of a force plate to measure maximum displacement of COM, the root mean squared (RMS) of the COP, or standard deviation of the COP.

Not placing the body in positions to challenge one's balance may increase the chances of falling while performing a task, impairing athletic performance, or increasing the risk of injury in sport. Standing upright and still is a complex regulation process of the body. The body is constantly trying to attain static balance, constantly swaying, although there is no visible motion. COP and COG are constantly oscillating during standing (Caron, Gelat, Rougier & Blanchi, 2000). This demonstrates that there is no stability in one's equilibrium (Nigg, Macintosh & Mester, 2000). Practicing yoga may improve both standing (static) and dynamic balance by increasing awareness of the body.

To date no research exist examining static and dynamic balance after yoga training. Therefore, the purpose of this study was to measure the effect of six weeks of yoga training on selected measures of static and dynamic balance.

METHODS: Initially, 30 healthy, adult males and females volunteered this study. Yoga participants were recruited from yoga classes being offered by a university to its students, staff, and faculty during the spring semester, 2005. Participants were free of any neurological conditions, and were new to yoga, having one or no prior sessions. Yoga training consisted of six weeks of Hatha yoga performed for 50 minutes twice a week. Hatha yoga incorporates mind, body and breath by controlling the breath and performing asanas. The classes were taught by a certified yoga instructor who purposely omitted the stork stand from the training since that was one of the balance positions tested on the force plate. The control group was recruited from the same university's community. Participants were free of any neurological conditions, and did not practice yoga, Tai Chi, or any similar activity. Participants in both groups were asked to refrain from changing their regular exercise routine outside of the scope of the study. This study was approved by the university's Institutional Review Board, and all participants signed an informed consent prior to testing. All participants underwent one static and two dynamic balance tests in the Biomechanics Laboratory prior to and at six weeks into the study. Tests were conducted using an AMTI force plate (Watertown, MA) sampling at 600 Hz, and a single 60 Hz color video camera (JVC, Wayne, NJ) positioned sagittal to the participant. The video tape was used to qualitatively review for touch downs that might have occurred during the balance tests. The Peak Motus software (ver. 8.2, ViconPeak, Centennial, CO) was used to derive the COP measures in both the anterior/posterior (A/P) and medial/lateral (M/L) directions. Verbal instructions as well as a demonstration by the principle investigator were given to the participants for the following tests.

The static test consisted of standing on the participant's stabilizing (used to hop) foot in the middle of an with the non-stabilizing leg flexed at the knee and the bottom surface of the foot placed on the knee of the stabilizing leg (Goldie et al., 1992; Kirby, Price & MacLeod, 1987). Hands were placed on the hips, and participants were asked to focus visually on an "x" placed on a wall 12 feet in front of them.

The dynamic balance tests were similar to the test previously described except the participants were asked to rhythmically swing the extended non-stabilizing leg in the frontal plane (medial to lateral) between two predetermined lines marked in front of them (M/L swing), and then again swinging the leg in the sagittal (anterior to posterior) between two predetermined lines marked on the floor with the non-stabilizing leg fully extended (A/P swing) (Hatzitaki, et al., 2002). A metronome set at a tempo of 60 bpm was used to assure that the same rhythm was kept for all test trials.

Data collection time for all three tests took place for 15 seconds. The first consecutive five seconds where a touch down did not occur was selected for analysis.

By week six, participant mortality occurred because of non-yoga related injuries and participant time conflicts. Thus, at week six, n_{yoga} = 6 and $n_{control}$ = 7. To evaluate mean differences in COP in the A/P and M/L directions for the three balance measures, 2 x 2 (group x time) mixed model ANOVAs were used, $p < .05$.

RESULTS: Participant demographics are depicted in Table 1.

Table 1 Participant Demographics.

Group	Age (yrs)	Height (cm)	Mass (kg)	Gender	
				Female	Male
Yoga	26.3±8.3	169.7±7.9	67.4±19.0	4	2
Control	28.7±6.34	174.0±13.9	68.2±20.4	5	2

Static stance: A 2x2 mixed model ANOVA was calculated to examine the effects of yoga and time on static balance scores, SD of the COP in the A/P direction. No significant main effects or interactions were found. The time by group interaction ($F(1,11) = .266$, $p > 0.05$), the main effect for time ($F(1,11) = 0.03$, $p > 0.05$), and the main effect for group ($F(1,11) = 1.16$, $p > 0.05$) were all not significant. Static balance, as measured by the SD of the COP in the A/P direction was not influenced by either time or group.
A 2x2 mixed model ANOVA was calculated to examine the effects of yoga and time on static balance scores, SD of the COP in the M/L direction. No significant main effects or interactions were found. The time by group interaction ($F(1,11) = 0.804$, $p > 0.05$), the main effect for time ($F(1,11) = 2.441$, $p > 0.05$), and the main effect for group ($F(1,11) = 1.08$, $p > 0.05$) were all not significant. Static balance, as measured by the SD of the COP in the M/L direction was not influenced by either time or group.
A/P Dynamic leg swing: A 2x2 mixed model ANOVA was calculated to examine the effects of yoga and time on A/P leg swing scores, SD of the COP in the A/P direction. No significant main effects or interactions were found. The time by group interaction ($F(1,11) = 0.006$, $p > 0.05$), the main effect for time ($F(1,11) = 5.19$, $p > 0.05$), and the main effect for group ($F(1,11) = 0.44$, $p > .05$) were all not significant. Dynamic balance, as measured by the SD of the COP in the A/P direction during an A/P leg swing was not influenced by either time or group.
A 2x2 mixed model ANOVA was calculated to examine the effects of yoga and time on A/P leg swing scores, SD of the COP in the M/L direction. No significant main effects or interactions were found. The time by group interaction ($F(1,11) = .069$, $p > .05$), the main effect for time ($F(1,11) = 1.32$, $p > 0.05$), and the main effect for group ($F(1,11) = 0.11$, $p > 0.05$). Dynamic balance, as measured by the SD of the COP in the M/L direction during an A/P leg swing was not influenced by either time or group.

Table 2 Means and Standard Deviations for Static and Dynamic Balance forYoga and Control Groups Pre and 6 weeks into the study.

Test	Yoga		Control	
	Pre (m)	6 wks (m)	Pre (m)	6 wks (m)
Static stance (A/P)	.001 ± .005	.048 ± .099	.008 ± .003	.009 ± .003
Static stance (M/L)	.009 ± .005	.018 ± .025	.006 ± .001	.009 ± .003
A/P leg swing (A/P)	.012 ± .003	.01 ± .002	.012 ± .002	.011 ± .012
A/P leg swing (M/L)	.009 ± .002	.016 ± .022	.009 ± .003	.021 ± .040
M/L leg swing (A/P)	.009 ± .002	.008 ± .012	.008 ± .002	.009 ± .003
M/L leg swing (M/L)	.007 ± .014	.007 ± .001	.010 ± .002	.020 ± .030

M/L Dynamic leg swing: A 2x2 mixed model ANOVA was calculated to examine the effects of yoga and time on M/L leg swing scores, SD of the COP in the A/P direction. No significant main effects or interactions were found. The time by group interaction ($F(1,11)=3.05$, $p>.05$), the main effect for time ($F(1,11) = 0.07$, $p > 0.05$), and the main effect for group in ($F(1,11) = 0.195$, $p > 0.05$) were all not significant. Dynamic balance, as measured by the SD of the COP in the A/P direction during an M/L leg swing was not influenced by either time or group.

A 2x2 mixed model ANOVA was calculated to examine the effects of yoga and time on M/L leg swing scores, SD of the COP in the M/L direction. No significant main effects or interactions were found. The time by group interaction (F (1,11) = 0.78, p > 0.05), the main effect for time (F (1,11) = 0.72, p > 0.05), and the main effect for group (F (1,11) = 1.48, p>0.05) were all not significant. Dynamic balance, as measured by the SD of the COP in the M/L direction during an M/L leg swing was not influenced by either time or group.
Table 2 depicts the means and standard deviations of the static and dynamic balance tests for both groups.

DISCUSSION AND CONLCUSION: The yoga groups mean SD of the COP for the medial lateral dynamic test stayed consistent throughout the study while the control groups increased. This finding indicates that even though the SD of the COP in the medial lateral directions were similar at the start, the yoga group was able to maintain medial lateral balance throughout the 6 weeks while the control group's medial lateral balance fluctuated during the dynamic tests.
Thornton, Sykes, & Tang (2004) measured balance using the functional reach test of 17 women; taking a 60 min Tai Chi class, 3 times per week for 12 weeks. Their findings showed Tai Chi improves balance. The results of the current study do not support this finding. Additionally, research by Boswell (1991) does not support this study. She tested 26 boys and girls to compare the effectiveness of two dance programs on static and dynamic balance. The durations of each program were 30 minutes 3 times per weeks for 24 sessions. The results revealed that the creative dance and movement exploration programs were effective in improving the dynamic balance of the participants using the stabilometer. Both these studies used functional tests to measure balance for 3 sessions per week for 8 to 12 weeks. The current study examined 6 weeks of yoga training. Findings may be difficult to compare since the studies stated above used functional tests instead of a force plate as a measuring tool. The functional tests may not be sensitive enough to measure all changes in balance thus; measurements for anterior posterior medial lateral were nonexistent.
Hatzitaki and colleagues (2002) used the maximum displacement of the center of mass to determine whether 11-13 year old children were capable of selecting a feedforward or feedback balance control system. The participants were tested for five second for each trial using the stork stand for static balance. The dynamic tests were similar to the stork stand except the participants swung the non-supporting limb as fast as possible. For the current study a similar stance was used to measure balance however, a metronome was used to keep a tempo and tape marked the distance the leg was to swing, preventing participants from swinging the leg faster or slower through a greater range or decreased of motion for each test trial.
We suggest a training stimulus of 2 sessions/wk and/or 6 wks of yoga is not adequate to significantly influence static and dynamic balance.

REFERENCES:
Bera, K. T. & Rajapurkar, M. V. (1993). Body composition, cardiovascular endurance and anaerobic power of yogic practitioner. *Indian Journal of Physiology and Pharmacology*, 37, 225-228.
Boswell, B. (1991). Comparison of two methods of improving dynamic balance of mentally retarded children. *Perceptual and Motor Skills*, 73, 759-764.
Caron, O., Gelat, T., Rougier, P. & Blanchi, J. P. (2000). A comparative analysis of the center of gravity and center of pressure trajectory path lengths in standing posture: An estimation of active stiffness. *Journal of Applied Biomechanics*, 16, 234.
Goldie, A. P., Evans, M. O. & Bach, M. T. (1992). Steadiness in one-legged stance: Development of a reliable force-platform testing procedure. *Archives of Physical Medicine and Rehabilitation*, 73, 348-354.
Hatzitaki, V., Zisi, V., Kollias, I. & Kioumourtzoglou, E. (2002). Perceptual-motor contributions to static and dynamic balance control in children. *Journal of Motor Behavior*, 34, 161-170.

Kirby, L. R., Price, A. N. & MacLeod, A. D. (1987). The influence of foot position on standing balance. *Journal of Biomechanics,* 20, 423-427.
Lan, C., Lai, J. & Chen, S. (2002). Tai chi chuan an ancient wisdom on exercise and health promotion. *Journal of Sports Medicine,* 32, 217-224.
Nigg, M. B., Macintosh, R. B. & Mester, J. (2000). Biomechanics and Biology of Movement. Champaign, IL: Human Kinetics.
Raub, A., J. (2002). Psychophysiologic effects of hatha yoga on musculoskeletal and cardiopulmonary function: a literature review. *The Journal of Alternative and Complementary Medicine,* 8, 797-812.
Tran, D. M., Holly, G. R., Lashbrook, J. & Amsterdam, A. E. (2001). Effects of hatha yoga practice on the health related aspects of physical fitness. *Preventive Cardiology, Fall* 2001.
Thornton, E.W., Sykes, S.K. & Tang, K. W. (2004). Health benefits of tai chi exercise: improved balance and blood pressure in middle-aged women. *Health Promotion Internationa.* 19, 33-38.
U.S. Department of Health and Human Services. (1996). *Physical activity and health: A report of the surgeon general executive summery. MMWR,* 12, 591-592.
Winter, D., A. (1990). *Biomechanics and Motor Control of Human Movement* (2nd ed.).