International Journal of Chinese Medicine
2017; 1(2): 62-69
http://www.sciencepublishinggroup.com/j/ijcm
doi: 10.11648/j.ijcm.20170102.14

Application of Yoga as an Effective Tool for Improving Postural Balance in Healthy Young Indian Adults

Kiran Mondal[1], Dhurjati Majumdar[2], Anilendu Pramanik[3], Subhojit Chatterjee[1], Manish Darmora[1], Deepti Majumdar[1, *]

[1]Defense Institute of Physiology and Allied Sciences, Delhi, India

[2]Institute of Nuclear Medicine and Allied Sciences, Delhi, India

[3]Faculty of Applied Science, Manav Rachana International University, Faridabad, India

Email address:

deepti@dipas.drdo.in (Deepti M.)

[*]Corresponding author

To cite this article:

Kiran Mondal, Dhurjati Majumdar, Anilendu Pramanik, Subhojit Chatterjee, Manish Darmora, Deepti Majumdar. Application of Yoga as an Effective Tool for Improving Postural Balance in Healthy Young Indian Adults. *International Journal of Chinese Medicine.* Vol. 1, No. 2, 2017, pp. 62-69. doi: 10.11648/j.ijcm.20170102.14

Received: February 27, 2017; **Accepted**: March 22, 2017; **Published**: April 10, 2017

Abstract: Since ages practicing Yoga is said to be a panacea and is assumed to play a multifaceted role in improving quality of human life even today. This study attempts to evaluate efficacy of short term Yoga training as a tool to improve postural balance in healthy young Indian adults. This was evaluated in terms of sway parameters during different standing postures expressed as Center of Pressure (COP), kinetic work and power responses of thirteen randomly selected healthy young adults, who participated in yoga training sessions for one-month involving five asanas viz., Suryanamaskar, Utkatasana, Brikshasana, Tuladandasana and Garurasana. A pair of Kistler Forceplates (model no. 9286 AA) and Bioware software were used to collect the COP, work and power data before initiation of yoga training (BY), after 15 days of yoga training (15D) and after 30 days of yoga training (30D) during five different standing postures i.e., normal standing while both feet placed as "V" shape (NS), no gap between feet (NG), both feet placed parallel with gap in between (PG), left leg stance (LS) and right leg stance (RS). It was observed from scatter plots that during experimental conditions NS, NG and PG, the COP (sway area) shifted towards midline. No such gradual changes were observed for both LS and RS but sway area increased for condition 30D. Both work and power responses either increased or remained same during different experimental conditions. Results indicate that yoga training could be used as an important tool for enhancing performances where postural stability is an important criterion, e.g., sports, agriculture and military operations.

Keywords: Yoga Training, Postural Stability, Centre of Pressure (COP), Work, Power

1. Introduction

Maintaining balance during bipedal locomotion in humans with either one or both feet contact with ground is the most complex and important phenomenon that has steadily come up with evolution. With two-thirds of our body mass located within two-thirds of body height above ground, man would have been in perpetual state of instability if no continuously acting control system was present. To increase the efficiency in posture and balance control, human feet has morphologically and functionally evolved towards limiting the excursion during ambulation that reduces energy expenditure involved and providing a base of support to maintain upright posture with least muscular activity. Further both the feet have specialized mechanism for flexibility to absorb the shock of the body weight, accommodate uneven terrain and increase their rigidity while they act as lever in the push-off period of stance [1]. The crux of physical fitness in humans, therefore, lies in efficient maintenance of both dynamic and static postural balance.

Today's youth, irrespective of occupation undertaken, faces extensive challenges that act as stressors and may deteriorate their health and performance over the years. These young adults venture in the fields of Industry, Sports and Athletics, Agriculture, Military and Para-Military forces where physical fitness is a necessity. Under present situations

of low intensity conflicts, an Indian infantry soldier needs to sustain harsh and hostile environment and yet remain combat fit for prolonged time. For them mobility and maneuverability are of utmost importance which are directly related to individual's capacity to maintain equilibrium and stability. Thus, it can be safely stated that if postural balance could be improved in these otherwise healthy young adults, their fitness and quality of life could be enhanced manifolds [2].

Measuring 'body sway parameters' during quiet standing is a good indicator of balancing capability of the individual and plays an important role in describing balanced body postures [3, 4]. Postural stability in terms of balance, power and work during quiet standing gives an overall information regarding balancing capacity of the individual. Postural Control is said to be body's capability to keep the body's centre of mass (COM) within the base of support during both static and dynamic postures. Winter (1995) showed that Center of Pressure (COP) in quiet stance almost synchronously reflected movement of Center of Mass (COM) [5]. Several studies in past have used one legged stance as tool for assessment of balance [6, 7 and 8]. Studying these responses might have significant implications in improving performance in different standing activities in military as well as industry, sports and agriculture sectors. It can be said that quantifying sway and static postural stability in healthy young individuals can indicate balancing capacity of young Indian population and can give some insight as to whether further some tools can be introduced for enhancing stability in them.

It is established by past researches that clinically, as an alternative medicine, yoga therapy is beneficial in improving balance in diseased and specially-abled individuals. Short term yoga practice was found to be beneficial for improving balance, strength, posture and gait in people with Multiple Sclerosis [9], Parkinson's disease [10, 11], visually impaired individuals [12], Alzheimer's patients [13], Arthritis patients [14], Obese individuals [15], women having musculoskeletal problems [16]. Many researchers have carried out studies to evaluate the effects of yoga interventions on 'fear of falling' and balance responses in elderly people [17, 18 and 19]. However, reported studies on effects of yoga on improvement in balance and postural stability in normal healthy adults are limited. A few review papers in literature have indicated that practicing Yoga could enhance many aspects of existing health and physical fitness including balance parameters, like ranges of motion, single legged stance and strength. According to the National Centre on Complementary and Alternative Medicine, practicing Yoga is one of the top 10 complementary health practices used by US adults and has been reported to increase wellbeing and quality of life for the general population [2]. The review paper by Jeter et al. (2014) concluded that improvement in balance was one of important benefits of yoga. This review also indicated that literature mostly concentrated on responses of Yoga interventions on individuals with pathology and disability but role of Yoga in improving 'balance' in otherwise healthy individuals have not been paid much attention so far and needs to be investigated scientifically. Unlike weight training and stretching exercises that focus on specific muscle groups, yoga focuses on 'asanas' or 'postures' that are 'whole body practices'. In practicing Yoga none of the body segment remains entirely passive [20].

Previous studies have established that 4 weeks of yoga training optimized sympathetic response to stressful stimuli and improved balance [18, 21]. Therefore, present study hypothesized that some measurable changes in balance and postural stability responses would be observed in normal healthy young adults with 30 days of yoga training in few selected asanas / postures that are known to improve balancing capabilities. The balance responses were evaluated in terms of COP, work and power observed before and after Yoga training.

2. Methodology

2.1. Participants

Thirteen randomly selected healthy young adult researchers, without any previous medical history of muscular dysfunction and neurological disorders, with mean±SD age, height and weight as 24.2±1.17yrs, 161.1±7.10 cm and 59.1±10.61 kg respectively, volunteered for the study. Though the sample size seems to be less than optimum required for attaining the objectives of such a study, increasing sample number at that point of time was not possible as subjects with similar stature and physical characteristics were not available. However past studies of similar nature have also been reported with smaller sample size. A study reported the effects of yoga on nocturnal awakening in young adults with sample size of 13 (22). The study by Sangiorgio et al. (2014) evaluated effects of yoga practice on prevention of bone mineral loss with a sample size of 9 female subjects (23). Out of 13 volunteers in present study, 7 were male and 6 were female. The data was not treated for gender variations as it has been previously established that sway, which is important in understanding the balance parameters, didn't vary across sexes [24].

2.2. Instrumentation

A pair of Kistler Force platforms (model no. 9286 AA, Kistler Instrumente AG, Winterthur, Switzerland) was used to collect the data at a sampling rate of 50 Hz using Bioware$^{(R)}$ software (Type 2812A1-3, Version 3.24 (7648)). As present study involved measurement of kinetic responses of only static postures, a sampling rate of 50Hz was thought to be adequate. The study by Majumdar et al. (2013) had used sampling rate of 200Hz for measuring kinetic parameters of gait while Indian soldiers walked carrying 17.5kg loads [25]. Another study by Teranishi et al. (2011) used sampling rate as low as 20Hz to validate sequence of postures used in standing test for imbalance and disequilibrium [26].

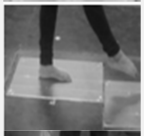
A DOS based software (J. A. Raymakers- 2000-2001) [27] was used to analyze COP displacement and area swiped during standing on forceplates.

2.3. Experimental Protocol

The experimental protocol was first approved by Institutional Ethics Committee. Accordingly, subjects were explained the purpose of the study and were allowed to familiarize with the laboratory, experimental design and kinetic data collection. The subjects signed informed consents before commencement of the study.

The volunteers practiced selected yoga postures namely Suryanamaskar, Utkatasana, Vrikshasana, Tuladandasana and Garurasana (as given in Figure 1) between 09:00 - 09:30 AM in the morning every day under guidance of Yoga Instructor continuously for 30 days. The given set of yoga asana postures were practiced twice during the duration with 5 minutes rest period. Kinetics data were collected before commencement of yoga training (BY), after 15 days of yoga training (15D) and then after 30 days of yoga training (30D) during five different experimental conditions of standing postures over the forceplate as described in Table 1.

Table 1. *Different standing postures used for data collection.*

Standing Posture	Abbreviation used	Visual
Normal standing while feet placed as "V" shape	NS	
Standing with no gap between feet	NG	
Standing with parallel gap between feet	PG	
Standing with left leg stance	LS	
Standing with right leg stance	RS	

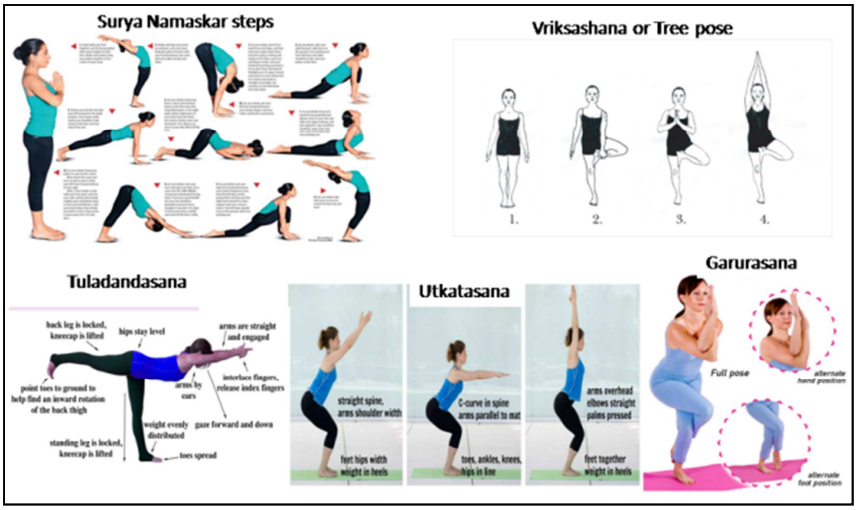


Figure 1. *The Yoga asanas practiced by subjects for the current study.*

2.4. Parameters Studied

Anterio-posterior (AP) and medio-lateral (ML) components of Center of Pressure (COP) were recorded. These parameters have significant role in describing balanced body posture [28]. Power and work data were computed in Bioware software using the displacements of the COP while the subjects held a particular posture. The area of COP (sway) was obtained using 'J. A. Raymaker's DOS based software' [27]. Units of measurements of COP, power, work and COP area are meter (M), watts (W), joules (J) and square-meter (sq. M) respectively.

2.5. Data Collection and Analysis

For each volunteer, data was recorded for 40 seconds while holding each of the experimental standing postures on the forceplates. First 10 seconds' data was excluded before analysis to avoid error while assuming each posture. Rest of the 30 seconds data was considered for analysis and subjected to statistical treatment. For each volunteer, three trials were recorded for each posture. Average values of three trials at 0th, 10th, 20th and 30th second were tabulated for each parameter. The Statistical Package for Social Sciences (SPSS) for Windows (Release 20; SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Three way repeated measure analysis of variance (ANOVA) for COP, Work and Power was carried out. A two way repeated measure ANOVA for 'Sway area' followed by Bonferroni post hoc test was applied for the pair-wise comparison of main effect within group. A value of $p<0.05$ was considered to be statistically significant.

3. Results

It was observed from the scatter plot between anterio-posterior and medio-lateral COP (Figure 2) that during experimental conditions NS, NG and PG, the COP (sway area) shifted towards midline. The trend of this shifting was BY>15D>30D for NS and PG; BY>30D>15D for NG. However no such gradual shift was observed for experimental conditions LS and RS. This may be due to small number of sample size.

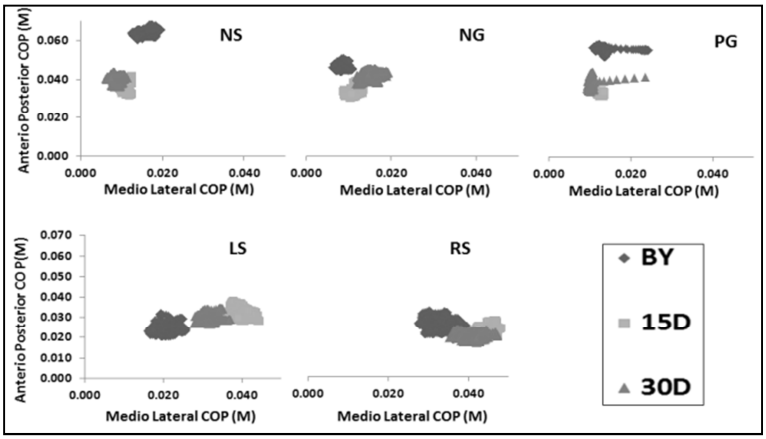


Figure 2. *Graphical representation of distribution of changes in COP (M) using a scatter plot for different standing postures.*

'Sway' or COP area was computed using Raymaker's DOS based software [27]. The statistical analysis using SPSS showed that there was an overall significant increase [F(2, 24)=35.706, p=0.000] in COP area for all the five experimental conditions after yoga training (Figure 3). The posthoc tests showed a significant increase for BY vs 15D and BY vs 30D at the level p=0.000. For all above conditions, the COP area showed an increase in magnitude while 15D was compared with 30D but the change was not significant.

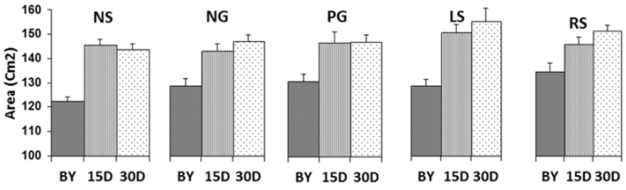


Figure 3. *Graphical representation of changes in sway area (sq. M) during different standing postures.*

The data for COP (mean±SEM) displacement was computed at 0th, 10th, 20th and 30th seconds of standing with given experimental postures on the forceplate (Figure 4). An overall significance was observed for anterio-posterior (AP) COP with day effect at F(1.346, 16.155)=4.163, p=0.048. However post hoc tests revealed that none of the changes were significant. A gradual decrease in AP COP for the experimental conditions NS, NG and PG were observed (Figure 4). For conditions LS and RS, values of AP COP increased for 15D as compared to BY and decreased for 30D as compared to 15D. However, values of parameters obtained for 30D was always found to be higher than that obtained for BY throughout the time line. The ML COP showed gradual decrease in 0th sec and 10th sec for the experimental conditions NS and NG, in 10th and 20th sec for PG and 30th sec for NG. These decrements were not significant. The data collected at 0th and 30th Second for PG and 20th sec for NG showed decrease in ML COP for 15D but increased for 30D. In case of 20th sec and 30th sec for NS this value showed an increase for 15D but again decreased for 30D. In case of LS and RS, ML COP showed an increase for 15D as compared to BY and then decreased for 30D.

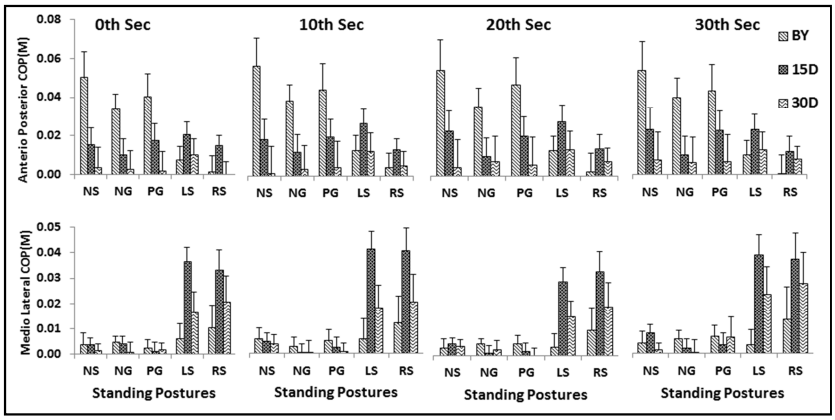


Figure 4. *Graphical representation of changes in COP (mean±SEM) displacement computed at 0th, 10th, 20th and 30th seconds during different static standing postures.*

The data for physical work and power were computed at 0^{th}, 10^{th}, 20^{th} and 30^{th} second of standing with given experimental postures on the force plate (Figure 5). Physical work was found to increase from BY to 15D and further after 30D in all experimental conditions. Power also increased linearly from BY to 15D and then to 30D in all experimental conditions. Magnitude of increase of both work and power individually were almost same in all experimental conditions and were statistically not significant.

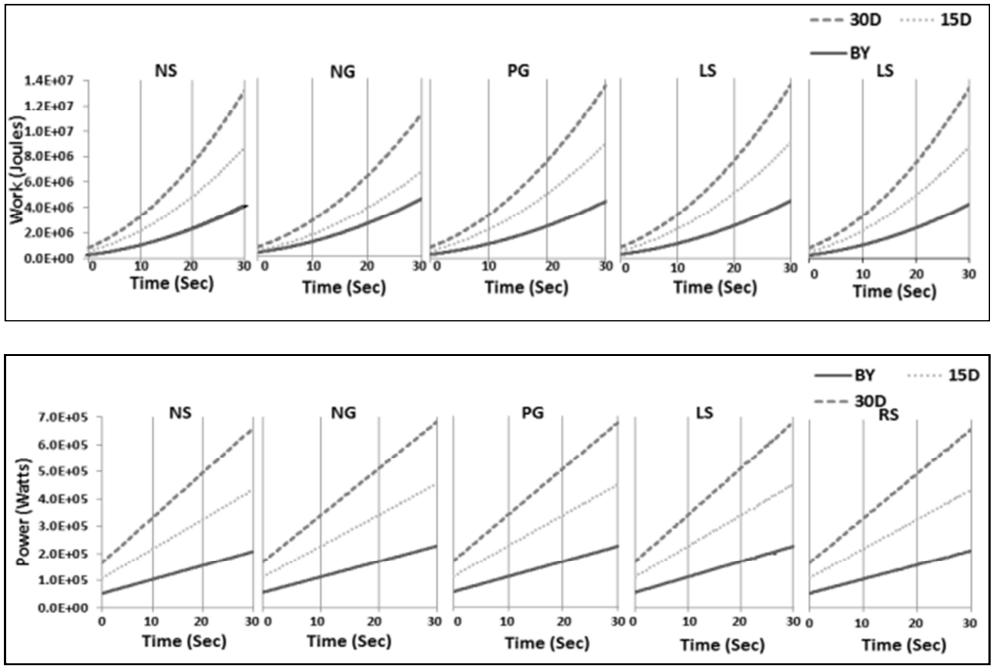


Figure 5. *Graphical representation of changes in Work (Joule) and Power (Watt) during different standing postures at different duration of yoga training.*

4. Discussion

Humans as bipeds, locomote over ground either by one foot contact or both feet contact with the ground. It is established that $2/3^{rd}$ of a main weight is located within $2/3^{rd}$ of body height above ground [1]. This in turn causes the human being to be in an inherent state of instability unless controlled continuously. This control is the balanced interfacing and interaction between basic anatomy, mechanics, neuromuscular controls etc. [5]. The ultimate goal of this interaction is to attain Postural Balance. The term 'Posture' of an individual describes the orientation of a body segment relative to gravitational vector. 'Balance' is a term that describes the dynamics of body posture that prevents falling and is related to inertial forces acting on the body and the inertial characteristics of the body segments. Maintenance of postural balance is most important for performing activities of daily living in any individual, such as, quiet standing, walking, running, etc. These activities may involve remaining stable in several positions, at the same time, reacting automatically and appropriately to voluntary body and limb movements and to external disturbances. While standing upright quietly, an individual has to bear his weight on two feet that are most uniquely engineered to hold human stance. The anatomy of human feet along with their musculature exhibit special abilities to reconcile and neutralize opposing forces [1].

In a review article, Proske and Gandevia (2012) discussed in detail the proprioceptive senses generated as result of our own actions, such as, senses of position, movement of limbs and trunk, senses of effort, force and heaviness. In this review they discussed several studies that elicited the importance and contribution of proprioceptive and vestibular systems in carrying out movement and maintaining posture [29]. Quiet standing is highly complex task involving integration of multiple body segments, joints and sensory systems in order to regulate balance while attempting to stay upright in a static position without moving. A healthy human being will always attempt to return to the COM within the base of support by regulating the body's position. The base of support is the displacement region for the COP as this measure serves as location point of the average distribution for all pressure over ground surface contact area. Therefore, it is established that by measuring the displacement of COP, an individual's balance can be evaluated [30]. The study by Neje et al. (2010) also used the COP movement during stance maintenance on a stable surface to describe and evaluate static balance. They stated that body sway is reflected in the movement of COM but for ease of evaluation and reporting the displacement of COP is commonly used. The stability of body in both AP and ML directions is influenced by width of the foot placement while the stability in sagittal plane is related to foot length. According to them, evaluating the biomechanical factors that influence 'body sway' may give more insight into clinical balance testing and goal directed

training. [3]. A review paper by Wang and Newell (2014) concluded that by assessing upright quiet stance using two force plates it is possible to record each individual foot COP and body weight distribution over the feet that help to interpret postural control mechanism [31].

Yoga is an ancient Indian science of well being, whose potential therapeutic benefits are now globally established. It includes short term and long term practice of different physical postures (asanas) which involve active involvement of whole body [32]. Past studies have shown positive effects of short term (6-8 weeks) practice of yoga to improve physical health conditions for older adults, young overweight and obese individuals [33], women with musculoskeletal problems [16], hypertensive individuals [34, 35] and individuals with Parkinson 's disease [11] apart from moderate to severe Alzheimer 's disease [13]. Most of these studies showed that yoga with its well formulated physical postures and controlled breathing techniques was most often successful in attaining the goal. A recent study carried out in Iran evaluated the effects of yoga practices on improving balance and reduction in 'fear of falling' in older adults (60-75 yrs). Results showed statistically significant changes with administration of yoga intervention [19]. A 12 week yoga intervention administered on 14 older adults above 65 yrs of age resulted in increase of lower body flexibility by 34% and decrease in fear of falling by 6% [18]. In a group of women (n=27) between 30 to 45 years of age with musculoskeletal problems (e.g., osteoarthritis and low back pain), an intervention of yoga program for a duration of 4 weeks produced positive effects on balance and gait parameters [16]. In another study by Madanmohan et al. (2013), positive results obtained after administration of 8 week duration yoga therapy program for management of hypertension in 15 patients indicated that the given comprehensive yoga therapy program had the potential to enhance the effects of standard medical management of essential hypertensive and could be used as a effective complimentary or integrative therapy program [9]. The study by Park et al. (2014) involving nine older adults with Alzheimer's disease who completed Sit 'N' Fit chair yoga program were found to improve balance and gait parameters [13]. The study by Ahmadi et al. (2010) indicated that even for patients with Multiple Sclerosis, yoga intervention could be beneficial due to improvement in balance, speed and endurance of walking and fatigue [9].

The review paper by Jeter et al. (2014) brings out the proven benefit of yoga in term of improvement in balance. This review also indicated that literature mostly concentrated on responses of Yoga interventions on individuals with pathology and disability. Role of Yoga in improving 'balance' in otherwise healthy individuals have not been paid adequate attention so far and needs to be investigated scientifically [2]. Unlike weight training and stretching exercises that focus on specific muscle groups, yoga focuses on 'asanas' or 'postures' that are 'whole body practices' and none of the body segment remains entirely passive [20]. Thus, current study attempted to assess balance in healthy young Indian adults during quiet standing and evaluate the efficacy of using short term yoga practices as a tool to improve balance parameters in same individuals in terms of displacement of COP, work and power. Measuring these parameters during quiet standing is a good indicator of balancing capability of the individual [3]. It has been established that body sway plays an important role in describing balanced body posture [4].

In the book entitled 'Yoga as Medicine', Dr Timothy McCall mentioned that Yoga increased proprioception and improved balance [36]. A study by Kittur et al. (2015) elicited the positive effects of Yogasana and Pranayama on physical and physiological parameters of 80 male adolescents. They concluded that 24 week Yogasana training improved physical capabilities of subjects including leg strength and flexibility [37].

Main inclusion criteria applied for selection of Yoga postures in the present study was 'improvement in balance'. Improved flexibility is one of the first and most obvious benefits of Yoga. With continued practice, there is gradual loosening of muscles and connective tissue surrounding the bones and joints, reducing aches and pains [37]. The study by Teranishi et al. (2011) elucidated some postures which are difficult to maintain for longer duration [26]. Based on their findings, the experimental postures for current study were selected for assessing the improvement in balance in our subjects with Yoga Intervention and are given in Table 1. Study by Vira et al. (2014) showed that Suryanamaskar enhanced both static and dynamic balance in young overweight and obese individuals [33]. According to the study by Greendale et al. (2012), the yoga postures, namely, Suryanamaskar, Utkatasana, Vrikshasana, Tuladandasana and Garurasanahave established balance and stability improvement capacity [38]. A review paper by Hewett et al. (2015) concluded that continued research into acute effects of yoga practices would enhance the understanding of physiological adaptation and will guide as to how practicing yoga can serve as a tool for improving balance in healthy young individuals [39].

An earlier study established that 4 weeks of yoga training optimized sympathetic response to stressful stimuli [34]. Therefore, as present study involved enhancement of static balance only, it was assumed that imparting 30 days of yoga practice would show some measurable improvement in our subjects, who were young healthy Doctoral scholars without previous experience of practicing yoga.

Primarily proven most obvious benefit of yoga is improved flexibility. Yoga helps to build muscle mass and/ or maintain muscle strength, which protects from conditions such as arthritis, osteoporosis and back pain (37). During a yoga session, the joints are taken through their full range of motion, squeezing and activating areas of cartilage not often used, thus bringing fresh nutrients, oxygen and blood to the area, preventing conditions like arthritis and chronic pain. Numerous studies have shown that asana, meditation or a combination of the two reduced pain in people with arthritis, Carpel Tunnel syndrome, back pain and other chronic conditions. Yoga also increased proprioception and improved balance, that is, the ability of an individual to maintain

body's center of gravity within its base of support and the process may be either static or dynamic, depending on the task involved [33, 40].

In the present study, it was found that after yoga training, COP area increased in most of the experimental postures while the COP area shifted towards midline in all double leg stance conditions. This may due to the fact that for maintaining postural stability COP displacements were on a wider surface increasing the base area for our participants and thus improving in postural stability. The stability of the body in both AP and ML directions is dependent on the width of foot placement while stability in sagittal plane is additionally influenced by length of feet [1, 3, 5]. The COP was displaced closer to body's midline indicated that minimum sway would occur. During double leg stance on 0^{th}, 10^{th}, 20^{th} and 30^{th} seconds AP COP displacement decreased. During BY, 15D and 30D conditions for single leg stance, COP displacement increased in 15D but decreased in 30D. The ML COP displacement also either decreased gradually or increased in 15D and then decreased in 30D. It was observed that the work and power during most of the experimental conditions increased when 15D and 30D data were compared with BY condition. An interesting observation was that, during BY conditions, erroneous fall of steps during asana was observed to be 30%-50% in our subjects. With 15D and 30D yoga training, the erroneous fall of feet completely ceased to occur, indicating improved balance with Yoga training. This may be explained in terms of better toning of muscle in our subjects with yoga training, thus increasing power generation which decreased body sway and increased the body's postural stability. The study by Josephson (1999) established that one of the determinants of muscle force was kinetics of muscle activation [40]. Thus an increase in overall muscle strength was thought to enhance stability and reduce the risk of injury [41]. Results of present study indicate that there is an evidence of improvement in static stability with short term yoga training in young and healthy adults. Therefore a long term Yoga training may bring about significant improvement in postural balance in these healthy young adults. Therefore, longitudinal studies to evaluate balance in terms of kinetics and sway parameters should be carried out on larger populations to understand the enhancement in performance due to yoga asanas training over varying duration of exposure for arriving at more concrete and precise inferences and future recommendations.

5. Conclusions

Present study indicates that short term (4 weeks) yoga training on selected 'standing posture' asanas may effectively improve the static stability of young Indian adults. Such intervention may help in enhancing performance in young healthy adults in sports, military and industries, at the same time reducing injury risk potential of the concerned task. Further longitudinal studies on larger number of subjects may help to identify the minimum time duration of yoga training intervention needed for optimizing the balance and posture in such populations.

References

[1] D. A. Winter, The ABC (Anatomy Biomechanics and Control) of Balance While Standing and Walking. Waterloo, Ont: Waterloo Biomechanics, 1995.

[2] P. E. Jeter, A-F. Nkodo, S. H. Moonaz, and G. Dagnelie, "Systematic review of yoga for balance in a healthy population," The journal of alternative and Complementary Medicine. Vol. 20, No. 4, pp. 221–232, 2014.

[3] S. Neje, R. Jernej, S. Loefler, and H. Kern, "Sensitivity of body sway parameters during quiet standing to manipulation of support surface size," J Sports Science and Medicine. Vol. 9, pp. 433-438, 2010.

[4] L. Chiari, L. Rocchi, and A. Cappello, "Stabiliometric parameters are affected by anthropometry and foot placement," Clinical Biomechanics. Vol. 17, pp. 666-677, 2002.

[5] D. A. Winter, "Human balance and posture control during standing and walking," Gait and posture. Vol. 3, pp. 193-214, 1995.

[6] K. Berg, S. Wood-Dauphinee, J. I. Williams, and D. Gayton, "Measuring balance in the elderly: Preliminary development of an instrument," Physiotherapy Canada. Vol. 41, pp. 304-311, 1989.

[7] R. W. Bohannon, and K. M. Leary, "Standing balance and function over the course of acute rehabilitation," Arch. Phys. Med. and Rehab. Vol. 76, No. 11, pp. 994–996, 1995.

[8] D. Frzovic, M. E. Morris, and L. Vowels, "Clinical tests of standing balance: performance of persons with multiple sclerosis," Arch Phys Med Rehabil. Vol. 81, pp. 215-221, 2000.

[9] A. Ahmadi, M. Nikbakh, A. A. Arastoo, and A. H. Habibi, "The effects of a yoga intervention on balance, speed and endurance of walking, fatigue and quality of life in people with multiple sclerosis," J Hum Kinetics. Vol. 23, pp. 71-78, 2010.

[10] Y. S. Colgrove, N. Sharma, P. Kluding, D. Potter, and K. Imming, "Effect of yoga on motor function in people with Parkinson's disease: a randomized, controlled pilot study," J Yoga Phys Ther. Vol. 2, pp. 112, 2012.

[11] E. Hall, G. Verheyden, and A. Ashburn, "Effect of a yoga programme on an individual with Parkinson's disease: a single-subject design," Disabil Rehabil. Vol. 33, No. 15-16, pp. 1483-9, 2011.

[12] P. E. Jeter, G. Dagnelie, S. B. S. Khalsa, S. Haaz, and A. K. Bittner, "Yoga for persons with severe visual impairment: a feasibility study", Alt. Medicine Studies. Vol. 2: e5, 2012.

[13] R. McCaffrey, J. Park, D. Newman, and D. Hagen, "The effect of chair yoga in older adults with moderate and severe Alzheimer's disease," Res Gerontol Nurs. Vol. 7, No. 4, pp. 171-7, 2014.

[14] S. H. Moonaz, C. O. Bingham, L. Wissow, and S. J. Bartlett, "Yoga in Sedentary Adults with Arthritis: Effects of a Randomized Controlled Pragmatic Trial," J Rheumatol. Vol. 42, No. 7, pp. 1194-202, 2015.

[15] C. Jorrakate, J. Kongsuk, C. Pongduang, B. Sadsee, and P. Chanthorn, "Effect of yoga training on one leg standing and functional reach tests in obese individuals with poor postural control," J Phys Ther Sci. Vol. 27, No. 1, pp. 59-62, 2015.

[16] O. Ulger, andN. V. Yağl, "Effects of yoga on balance and gait properties in women with musculoskeletal problems: a pilot study," Complement Ther Clin Pract. Vol. 17 No. 1. pp. 135, 2011.

[17] A. Tiedemann, S. O. Rourke, R. Sesto, and C. Sherrington, "A 12-week Iyengar yoga program improved balance and mobility in older community-dwelling people: a pilot randomized controlled trial," J Gerontol A Biol Sci Med Sci. Vol. 68, No. 9, pp. 1068-75, 2013.

[18] A. A. Schmid, M. Van Puymbroeck and D. M. Koceja, "Effect of a 12-week yoga intervention on fear of falling and balance in older adults: a pilot study," Arch Phys Med Rehabil. Vol. 91, No. 4, pp. 576-83, 2010.

[19] N. Nick, P. Petramfar, F. Ghodsbin, S. Keshavarzi, and Jahanbin, "The effect of yoga on balance and fear of falling in older adults," PMR. Vol. 8: pii: S1934-1482 No. 15, pp. 00751-0, 2015.

[20] L. Kaminoff, Yoga Anatomy. Published by Human Kinetics, USA ISBN-13: 978-0-7360-6278-5, 2007.

[21] K. M. Chen, and W. S. Tseng, "Pilot-testing the effects of a newly developed silver yoga exercise program for female seniors," J Nurs Res. Vol. 16, pp. 37-46, 2008.

[22] R. S. Kudesia and M. T. Bianchi, "Decreased nocturnal awakenings in young adults performing Vikrama Yoga: a low-constraint home leep monitoring study," ISRN Neurology, vol 2012, Article ID 153745, 7 pages, 2012.

[23] S. N. Sangiorgio, A. K. Mukherjee, N. W. Lau, A. Mukherjee, P. Mukhopadhyay, and E. Ebramzadeh, "Optimization of physical activity as a countermeasure of bone loss: a 5 year study of Vikram Yoga in females," Health, vol 06, no. 11, pp 1124-1132, 2014.

[24] H. Rogind, J. J. Lykkegaard, H. Bliddal, and B. Danneskiold-Samsoe, "Postural sway in normal subjects aged 20-70 years," Clin Physiol Funct Imaging. Vol. 23, No. 3, pp. 171-6, 2003.

[25] D. Majumdar, M. S. Pal, A. Pramanik, and D. Majumdar, "Kinetic changes in gait during low magnitude military load carriage," Ergonomics. Vol. 56, No. 12, pp. 1917-1927, 2013.

[26] T. Toshio, K. Izumi, S. Shigeru, W. Yosuke, M. Hiroyuki, T. Genichi, N. Wataru, S. Hiroaki, O. Makoto, and S. Eiichi, "Validity study of the standing test for imbalance and disequilibrium (SIDE): Is the amount of body sway in adopted postures consistent with item order?", Gait and Posture. Vol. 34, pp. 295-299, 2011.

[27] J. A. Raymakers, M. M. Samsan, and H. J. Verhaar, "The assessment of body sway and choice of stability parameters," Gait and Posture. Vol. 21, pp. 48-58, 2005.

[28] L. Chiari, L. Rocchi, and A. Cappello, "Stabiliometric parameters are affected by anthropometry and foot placement", Clinical Biomechanics. Vol. 17, pp. 666–677, 2002.

[29] U. Proske, and S. C. Gandevia, "The proprioceptive senses: their roles in signaling body shape, body position and movement, and muscle force", Physiol Rev. Vol. 92, pp. 1651-1697, 2012.

[30] P. X. Ku, N. A. A. Osman, A. Yusof, and W. A. B. W. Abas, "The effect on human balance of standing with toe extension," Plos-one. Vol. 7, No. 7, pp. 4, ID: e41539, 2012.

[31] Z. Wang, and K. M. Newell, "Inter-foot coordination dynamics of quiet standing postures," Neuroscience and Behavioural Reviews. Vol. 47, pp. 194-202, 2014.

[32] H. C. Shashikiran, S. Shetty, P. Shetty, and R. K. Chetan, "A study on Influence of Yoga on Autonomic variables on Young Adults," Int. J Innovative Research & Development. Vol. 4, No. 2, pp. 267-274, ISSN 2278-0211 (online), 2015.

[33] J. Vira, U. Pandit, and P. D. Majumder, "The effect of Suryanamaskar on static and dynamic balance in young overweight and obese individuals," Int. J. of Science & Research. Vol. 10, No. 3, pp. 1519-1522, 2014.

[34] P. Vijayalakshmi, Madanmohan, A. B. Bhavanani, A. Patil, and K. Babu, "Modulation of stress induced by isometric handgrip test in hypertensive patients following yogic relaxation training," Indian J Physiol Pharmacol. Vol. 48, No. 1, pp. 59-64, 2004.

[35] A. Madanmohan, B. Bhavanani, Z. Sanjay, L. Vithiyalakshmi, and G. Dayanidy, "Effects of eight week yoga therapy program on cardiovascular health in hypertensives," Indian Journal of Traditional Knowledge. Vol. 12, No. 3, pp. 535-541, 2013.

[36] T. McCall, "Yoga as Medicine," New York: Bantam Dell a division of Random House Inc, 2007.

[37] R. H. Kittur, G. Prabhu, Madialagan, and M. B. Karlwad, "Effects of selected yogasana and pranayama practice on physical capabilities of male adolescents," Int. J of Engg Res & Sports Sci. Vol. 2, No. 4, pp. 1-4, 2015.

[38] G. A. Greendale, L. Kazadi, S. Mazdyasm, E. Ramirez, M-Y. Wamg, SS-Y. Yu, and G. Salem, "Yoga empowers senior study (YESS): design and asana series," J Yoga Phys Ther. Vol. 2, No. 1, pp. 1-17, 2012.

[39] Z. I. Hewett, S. C. Cheema, K. L. Pumpa, and C. A. Smith, "The effects of Bikram Yoga on health: critical review and clinical trial recommendations," In: Evidence-Based Complementary and Alternative Medicine. pp 13, 2015, Article Id: 428427. Hindawi Publishing Corporation; http://dx.doi.org/10.1155/2015/428427.

[40] C. Woodyard, "Exploring the therapeutic effects of yoga and its ability to increase quality of life," Int. Jof Yoga. Vol. 4, No. 2, pp. 49.54, 2011.

[41] R. K. Josephson, "Dissecting muscle power output," The J of Exp. Biol. Vol. 202, pp. 3369–3375, 1999.