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Postural stability and flexibility responses of yoga training in women: Are improvements similar in both sexes?

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ABSTRACT
The researchers' aim is to examine the postural stability and flexibility responses of yoga training in women. The authors conducted the yoga training program 2 days a week and they assessed flexibility using the sit and reach test, trunk hyperextension test and trunk lateral flexion test. The researchers measured static and dynamic balance employing the device and database system. Then, the authors repeated all assesments were at the end of the first, the fifth and the tenth sessions. As a result of this study, the researchers revealed that the male participants had significantly poorer results in a single parameter (longitudinal sway) when compared with the female group, but the groups were statistically equivalent in this parameter after the first yoga training session. The authors also revealed that yoga was effective in improving flexibility among healthy young adults of both sexes, although the males showed greater improvement than females in the flexibility results.

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There is a piece of increasing evidence that complementary and alternative approaches can benefit health. Yoga is one of these methods and a complementary healthcare approach. Besides, it is a holistic method that can provide results that are equivalent to active methods and even have some advantages (Shashikiran et al., 2015). The use of yoga as a healthcare approach for healthy and patient populations is becoming increasingly common (Mondal et al., 2017; Schmid et al., 2012). Yoga is thought to regulate nervous system and the functioning of physiological system. It is also known to improve psychological health and physical fitness (Wren et al., 2011). Due to the effects of yoga in the field of health and being a safe practice, it can be used in many areas of health. There is even evidence that it can be used safely during pregnancy, chronic diseases

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such as cancer and in elderly individuals who are vulnerable to injury (Kwon et al., 2020; Siedentopf et al., 2013). In fact, current evidence shows that individuals of all ages can benefit from yoga to improve health-related parameters and it has a more holistic effect on older adults compared to walking, aerobics, and other physical activities (Östh et al., 2019).

Researchers define postural stability as the ability to control the center of gravity within a given support base, including both static and dynamic conditions, resulting from synchronous integration of sensory and motor function. In normal stance, body sway parameters of measurement is a good indicator of an individual's balance capacity and play an important role in defining balanced body posture (Farinatti et al., 2014; Shetty et al., 2018). There are some studies in the literature providing evidence that yoga may be an exercise intervention that can be used to improve postural stability (de Haart, Geurts, Huidekoper, Fasotti, & van Limbeek, 2004; Nejc, Jernej, Loefler, & Kern, 2010). However, the number of studies investigating the effects of yoga on balance and postural stability in healthy adults is insufficient (Mondal et al., 2017; Chiari et al., 2002). In addition, to the best of our knowledge, there is no study examining the effect of yoga on flexibility, dynamic and static postural stability responses in young adults. The most known effect of yoga is on flexibility. Some factors, such as sex, age, and individual differences, effect flexibility (Lynton et al., 2007). However, most of the studies about yoga and flexibility have been done in elderly individuals (Hazelhurst & Claassen, Hazelhurst and Claassen, Hazelhurst and Claassen, 2006; Subramaniam & Bhatt, 2017) and there is insufficient information to explain the effect of yoga on flexibility in healthy young adults (Hunter, 2016).

When the physiological characteristics of skeletal muscle in men and women are examined, differences that may affect the response to exercise emerge (Ansdell et al., 2020). Sex-related differences in exercise practices have been studied in many studies and the effects of these differences were tried to be understood (Fomin et al., 2012; Sheel, 2016). In a study examining cardiovascular responses during isometric exercise at different positions; the researchers found that women had lower blood pressure rates than men in terms of blood pressure responses to isometric exercise (Miller et al., 1993). In a different study in which the researchers examined sweat response during spinning exercise, the authors determined that men had a higher sweat rate than women (Fomin et al., 2012). In another study, Sheel (2016) found that sex differences can create differences in performance fatigue specific to different task demands. Similar to this research, in another study evaluating sex differences in terms of muscle fiber and strength by Marongiu, and Crisafulli (2015), differences between the sexes in terms of both parameters were determined. In another study, it was stated that weak hamstring peak strength compared to quadriceps peak strength in female athletes may predispose to injury by reducing the ability to control coronal and sagittal plane knee motion (Hewett et al., 2005). Similarly, low hamstring/quadriceps ratio increases the stress on the anterior cruciate ligament by causing a decrease in joint stability, which may increase the rate of knee injury (Magalhaes et al., 2004). The authors in these studies emphasized that it is important to determine the responses of women and men to exercise and that different protocols should be developed considering these differences (Fomin et al., 2012; Sheel, 2016; Miller et al., 1993; Marongiu, & Crisafulli, 2015; Hewett et al., 2005; Magalhaes et al., 2004). In addition, the researchers also pointed out in these studies that information on sex differences in exercise physiology is still unclear and different in the literature.

There are many physiological and anatomical differences between men and women. Understanding of these differences can provide the opportunity for the development of sex-specific training/exercise programs for healthy and patient populations (Fomin et al., 2012; Sheel, 2016; Marongiu, & Crisafulli, 2015).

The call for health promotion is constantly repeated. Large organizations such as the World Health Organization (WHO, 2021) and ACSM constantly emphasize that the individual's health requires multi-faceted strengthening. Although research appears to focus on methods that can be done in disease conditions, it is essential to strengthening the body and mental health in order to both live healthy and adopt cost-effective practices (WHO: Coronavirus disease pandemic, n.d.).

As it is known, in a pandemic process such as COVID-19, the world recalled the importance of its strong health infrastructure (WHO: Strengthening the health system response to COVID-19, n.d.). In order to reduce the long-term effects of social isolation, leading organizations call for activity at home (WHO: Physical-activity, n.d.). From this point of view, it is seen how important programs that will develop strength and skill for healthy individuals are. As explained before, researchers investigate sex-specific responses of practices in many studies (Shashikiran et al., 2015; Fomin et al., 2012; Marongiu, & Crisafulli, 2015). The authors emphasized in these studies that sex-related differences are valuable to increase the effectiveness of the methods.

Although the positive effects of yoga on health are well known, the researchers planned this study to examine whether yoga would have a positive contribution to postural control skills in people who are already known to be healthy (Subramaniam & Bhatt, 2017; Diamond, 2012). Since there is no research, to the best of our knowledge, aiming to find out the aforementioned gaps in the literature, the researchers aim to determine the effect of yoga training on postural stability and flexibility responses among women and to examine sex-related differences in this study.

Material and Methods

The researchers planned this study in a descriptive and cross-sectional study design. This study protocol was approved by the Trakya University Medical Faculty Research Ethics Committee. Besides, the researchers obtained written informed consent forms from the participants.

Participants

The authors calculated the sample size of the study as 80% power and 0.3 effect size using the G-Power program and 36 university students (16 females and 20 males) were included in this study. The researchers determined the inclusion criteria as (a) having no health problems; (b) being at the ages between 18-25 years; (c) having no regular exercise and/or yoga history for the last one year; (d) having the normal body mass index according to the intervals determined by the World Health Organization (WHO: Body Mass Index, n.d.).

Study procedures

The demographic information of the individuals was recorded by the researchers and they repeated the flexibility and balance assessments at the end of the first, the fifth, and the tenth sessions. In this study; yoga training was conducted by the first physiotherapist, while flexibility measurements were performed by the second physiotherapist. The balance measurements were made by the third physiotherapist and physician.

The authors assessed flexibility utilizing the sit and reach test, trunk hyperextension test, and trunk lateral flexion test. A sit and reach box was used for the sit and reach test. For the test, the participants sat with legs extended and feet flat against the box and reached forward over the ruler with both hands while keeping their knees extended. The edge of the table was scored as zero points; distances between the edge of the table and middle finger farther from the table were considered positive and, the opposite distance to the table were considered negative by the researchers.

The authors recorded difference between the initial position and the point reached distance was recorded in centimeters (cm). They repeated the test three times and the maximum distance was recorded. To assess trunk hyperextension, the participants stood facing a wall by maintaining entire pelvis and trunk against the wall. The researchers measured the distance between the wall and sternal notch and recorded as the initial value. Then the researchers asked the participants to move their upper body away from the wall. The distance between the wall and sternal notch was measured again. Then, they subtracted the initial distance from this value and recorded the amount of movement in cm. In the assessment of trunk lateral flexion, the researchers asked the participants to stand in their comfortable position and marked the the position of the distal point of the third finger of the right hand on their thigh. Next, the authors asked the participants to perform lateral flexion and they marked the position of the distal point of the third finger on their thigh again. Finally, they measured the distance between the two marks and recorded it in cm. The researchers repeated the test three times on both sides and recorded the highest values (Golding & Journal, 1997).

The authors measured balance using the balance analysis section of the Zebris© CMS20P-2 device and the WinBalance database system (Cigali et al., 2011). For balance analysis, the researchers positioned the participants with their back toward the measurement sensor, eyes focusing straight ahead on any target and their body in the upright position. Then, the authors adjusted the distance between the measurement sensor and the participant was adjusted to approximately 70 cm. Before the measurement, the researchers fitted the participants with a specialized helmet and shoulder pads with markers attached. Later, they placed an adaptor to connect the cables extending from the helmet and shoulder pads was placed near the participant's waist. Then, they connected the cables from the helmets to two adaptor input ports and connected the cables from the shoulder pads to the other two input ports as well. Next, they attached an adaptor to the measurement sensor using a thin cable. The researchers also adjusted the noise, temperature, and light levels in the assessment setting to prevent any effect of these factors on the participants. They set the measurement duration to 60 seconds. The authors explained the measurement procedure and demonstrated it to the participants as well. They discarded the data and repeated the measurement if the participants did not meet the measurement criteria.

For the Standing test; the researchers asked the participants to extend their arms forward parallel to the ground at the chest level, with the eye closed with the eye facing the sensor. The participants pressed their heels firmly on the floor. During this time, the implementers calibrated the equipment and they instructed the participants not to move, laugh, or talk for 60 seconds while the measurements were obtained. The authors saved the acquired data on a computer and they recorded four parameters for the Standing Test. While the first and the second parametres, which are called as Lateral sway (Lats), express the amount of lateral displacement of the helmet markers, the third one, which is Longitudinal sway (Lons), represents the anterior/posterior movement of the head and shoulders during the test. The fourth parameter, which is Forehead cover area (Fca) corresponds to the area covered by the marker located on the front of the helmet. Torticollis Angle (Ta) expresses the angle between the head and shoulder positions at the end of the posture test.

For the Stepping Test, the participant closed their eyes and stood in the same position as for the Standing Test while the researchers calibrated the equipment. Then the implementers instructed the participants to perform on-site stepping in place for 60 seconds while they performed measurements. The researchers provided help for the participants in order they stepped properly and in the correct place during the test. Next, the implementers saved the acquired data on a computer. Four parameters were recorded for the Stepping Test: Longitudinal deviation (Ld) refers to the distance between where the subject started and ended the test; lateral sway width (Latsw) refers to the maximum lateral sway of the head and shoulders; angular deviation (Ad) refers to the angle of deviation between the line connecting the starting and ending points of the test and the midline; and self-spin (Ss) refers to the angle of body rotation around its own axis. In the program, the rightward rotation was considered negative and leftward rotation was considered positive (Morioka, Hiyamizu, & Yagi, 2005). (Figures 1 and 2).

Yoga training

The participants attended the yoga training program 2 days a week under the supervision of a physiotherapist with yoga instructor certificate (Yoga Alliance). They received a total of 10 sessions of yoga sessions. The training took place in the practice class in Trakya……. University Faculty of Health Sciences on Tuesday and Thursday between 17.30-18.30. The first session of yoga training started by talking about yoga philosophy, the aim of this study and exercises in different stages. After the researchers and the participants discussed the importance of breathing (pranamaya), the participants learned how to breathe properly in this phase. All yoga sessions consisted of breathing, relaxation, yoga poses (asanas) and relaxation. Each session lasted approximately 60 minutes and participants' individual differences were carried out considering the applications. The training program is summarized in Table 1.

Figure 1. Standing and stepping test.

Statistics analysis

The researchers tested variables for normal distribution using the one-sample Kolmogorov–Smirnov test. Then, they expressed the results employing the mean ± standard deviation (SD). Because the variables did not conform to normal distribution, the authors conducted the comparisons between the sexes utilizing Mann–Whitney U test and they employed Wilcoxon test to analyze intragroup variables. The researchers considered a p-value <0.05 statistically significant. They used Statistical Package for the Social Sciences for Windows version 22.0 package program (IBM Corp.; Armonk, NY, USA) for all statistical analyses.

Results

Although 36 individuals enrolled initially, 28 participants (15 females and 13 males) completed the study. One woman and four men withdrew from the study after the first session because they said they could not attend the sessions regularly. Three men participants quit the study after the second session without giving a reason.

There were no significant differences between the male and female participants in terms of age, tobacco use, exercise habits and body mass index ($p > 0.05$). The mean ages of the male and female students were 20.62 ± 1.19 and 20.60 ± 1.18 years, respectively.

The researchers revealed that yoga training had a positive effect on the flexibility values in both groups ($p < 0.05$). The measurement results are shown in Tables 2 and 3.

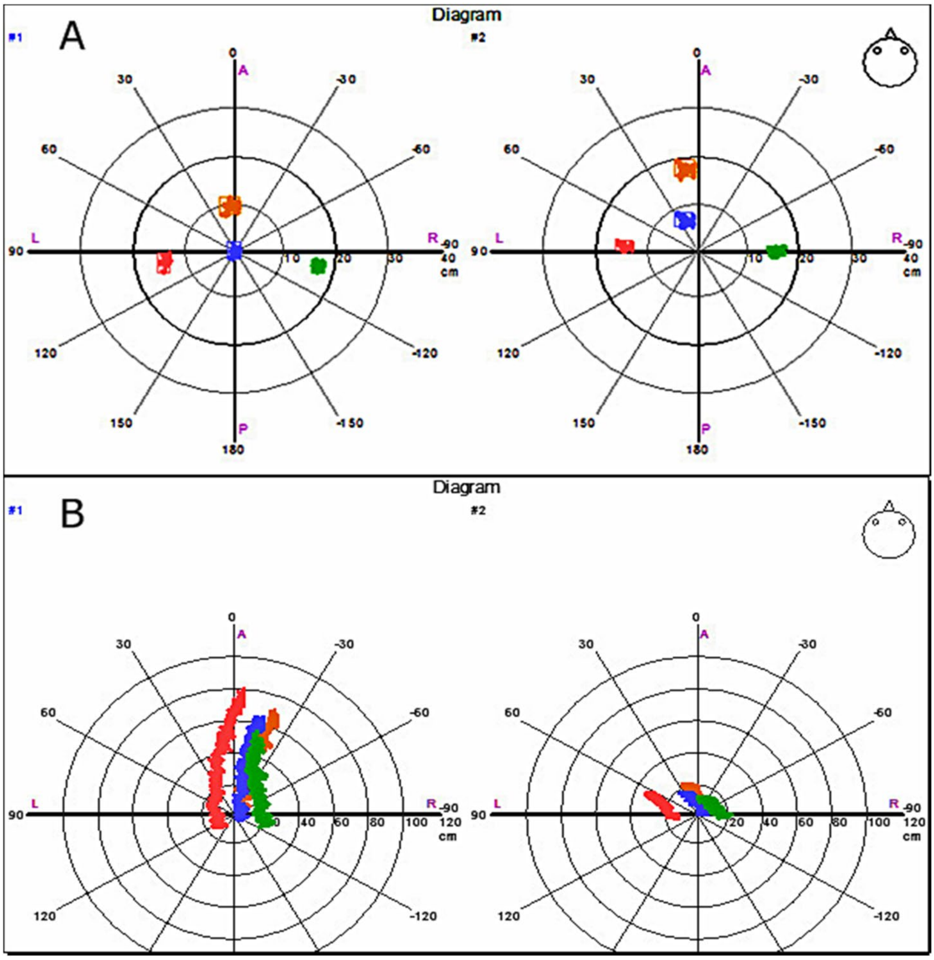

Figure 2. a)Standing test measurement report diagram b)Stepping test measurement report diagram.

The researchers evaluated the participants' static and dynamic balance at four different time points. Initially, the male participants had significantly poorer results in a single parameter (longitudinal sway) when compared with the female group ($p = 0.011$), but the groups were statistically equivalent in this parameter after the first yoga training session ($p > 0.05$). Through the analysis of temporal changes, the authors detected that dynamic stability developed in both groups after the first session ($p < 0.05$) and then reached a plateau ($p > 0.05$). In other words, in healthy individuals, yoga training contributes to postural stability with a single session, but subsequent sessions do not contribute further to this improved stability. The results are shown in Tables 4, 5, and 6.

Table 1. Yoga training program.

Session	Content
1	pranamaya, virabhadrasana 2, parivrtta virabhadrasana, utthita trikonasana, utthita parsvakonasana, utthita ashwa sanchalanasana, eka pada rajakapotasana, phalakasana, chaturanga dandasana, vasisthasana, adho mukha svanasana, bhujangasana, ananda balasana, *shavasana*
2	pranamaya, uttanasana, ardha uttanasana, ardha parsvottanasana, parsvottanasana, prasarita padottanasana, malasana, bakasana, purvottanasana, dandasana, upavistha konasana, parsva upavistha konasana, *shavasana*
3	pranamaya, tadasana, uttanasana, virabhadrasana 1, ardha parsvottanasana, virabhadrasana 2, utthita trikonasana, dandanasana, janu sirsasana, phalakasana, adho mukha svanasana, ardha bhujangasana, salamba bhujangasana, pawanmuktasana, *shavasana*
4	pranamaya, virabhadrasana 2, utthita trikonasana, utthita ashwa sanchalanasana, ardha parsvottanasana, tadasana, utkatasana, anjaneyasana, phalakasana, chaturanga dandasana, salamba sarvangasana, setu bandha sarvangasana, eka pada setu bandha sarvangasana, vajrasana, gomukhasana, shavasana
5	pranamaya, surya namaskara, virabhadrasana 1, ardha parsvottanasana, parsvottanasana, dandanasana, paschimottanasana, janu sirsasana, phalakasana, vasisthasana, adho mukha svanasana, ardha bhujangasana, bhujangasana, baddha konasana, supta baddha konasana, pawanmuktasana, jathara parivartanasana, shavasana
6	pranamaya, virabhadrasana 1, virabhadrasana 2, utthita trikonasana, utthita ashwa sanchalanasana, eka pada rajakapotasana, phalakasana, vasisthasana, adho mukha svanasana, urdhva mukha svanasana, ustrasana, balasana, ananda balasana, shavasana
7	Pranamaya, virabhadrasana 2, utthita trikonasana, ardha chandrasana, virabhadrasana 1, virabhadrasana 3, dandanasana, krounchasana, trianga mukhaikapada paschimottanasana, dolphin plank, dolphin, salamba sirsasana, ardha bhekasana, bhekasana, supta padangusthasana, shavasana
8	pranamaya, virabhadrasana 2, parivrtta virabhadrasana, utthita trikonasana, utthita parsvakonasana, parivrtta parsvakonasana, utthita ashwa sanchalanasana, parsvakonasana, anjaneyasana, phalakasana, chaturanga dandasana, eka pada rajakapotasana, balasana, ananda balasana, shavasana
9	pranamaya, virabhadrasana 2, utthita parsvakonasana, parivrtta parsvakonasana, virabhadrasana 3, vrksasana, utthita hasta padangusthasana, parivrtta hasta padangusthasana, marichyasana, gomukhasana, phalakasana, bakasana, halasana, ustrasana, ardha navasana, navasana, jathara parivartanasana, shavasana
10	pranamaya, parsvakonasana, tadasana, uttanasana, ardha uttanasana, prasarita padottanasana, sirsasana, janu sirsasana, parivrtta janu sirsasana, pincha mayurasana, salamba sarvangasana, matsyasana, marjaryasana, bitilasana, ananda balasana, shavasana

Table 2. Flexibility measurement results of male and female participants before yoga training and after sessions 1, 5, and 10.

Parameters	Female (n:15) Mean ± Sd	Male (n:13) Mean ± Sd	p
SR BYT	−0.27 ± 7.39	−2.62 ± 9.63	0.595
HExt BYT	27.37 ± 3.14	30.31 ± 3.61	**0.021***
RLF BYT	43.03 ± 3.68	46.85 ± 4.72	**0.022***
LLF BYT	43.50 ± 3.96	47.27 ± 4.74	**0.032***
1st SR	1.87 ± 6.44	−1.46 ± 10.56	0.596
1st HExt	29,03 ± 2.43	32.31 ± 2.75	**0.004***
1st RLF	41.53 ± 3,52	45.19 ± 3.99	**0.017***
1st LLF	41.83 ± 4.11	45.54 ± 4.07	**0.027***
5th SR	4.10 ± 5.44	1.58 ± 9.73	0.474
5th HExt	31.13 ± 2.33	34.00 ± 1.70	**0.001***
5th RLF	40.63 ± 3.43	44.42 ± 4.00	**0.012***
5th LLF	40.83 ± 3.97	44.58 ± 3.63	**0.017***
10th SR	7.23 ± 5.61	5.35 ± 9.97	0.695
10th HExt	32.10 ± 2.41	35.88 ± 2.45	**0.001***
10th RLF	39.77 ± 3.58	42.73 ± 3.57	**0.044***
10th LLF	39.77 ± 3.70	42.88 ± 3.23	**0.040***

SR: sit and rich; BYT: before yoga training; HExt:Hyperextension;
RLF: right lateral flexion; LLF: left lateral flexion;
Mann–Whitney U test.

Table 3. Comparison of flexibility measurement results of male and female participants between yoga training sessions.

Sessions	Female (n:15) Mean ± Sd		p	Male (n:13) Mean ± Sd		p
SR BYT - 1st SR	−0.27 ± 7.39	1.87 ± 6.44	**0.005***	−2.62 ± 9.63	−1.46 ± 10.56	**0.042***
1st SR - 5th SR	1.87 ± 6.44	4.10 ± 5.44	**0.002***	−1.46 ± 10.56	1.58 ± 9.73	**0.003***
5th SR - 10th SR	4.10 ± 5.44	7.23 ± 5.61	**0.001***	1.58 ± 9.73	5.35 ± 9.97	**0.001***
HExt BY - 1st HExt	27.37 ± 3.14	29.03 ± 2.43	**0.004***	30.31 ± 3.61	32.31 ± 2.75	**0.005***
1st HExt - 5th HExt	29.03 ± 2.43	31.13 ± 2.33	**0.003***	32.31 ± 2.75	34.00 ± 1.70	**0.018***
5th HExt - 10th HExt	31.13 ± 2.33	32.10 ± 2.41	**0.075**	34.00 ± 1.70	35.88 ± 2.45	**0.007***
RLF BYT - 1st RLF	43.03 ± 3.68	41.53 ± 3.52	**0.002***	46.85 ± 4.72	45.19 ± 3.99	**0.008***
1st RLF - 5th RLF	41.53 ± 3.52	40.63 ± 3.43	**0.026***	45.19 ± 3.99	44.42 ± 4.00	**0.027***
5th RLF - 10th RLF	40.63 ± 3.43	39.77 ± 3.58	**0.017***	44.42 ± 4.00	42.73 ± 3.57	**0.005***
LLF BYT - 1st LLF	43.50 ± 3.96	41.83 ± 4.11	**0.002***	47.27 ± 4.74	45.54 ± 4.07	**0.005***
1st LLF - 5th LLF	41.83 ± 4.11	40.83 ± 3.97	**0.007***	45.54 ± 4.07	44.58 ± 3.63	**0.027***
5th LLF - 10th LLF	40.83 ± 3.97	39.77 ± 3.70	**0.002***	44.58 ± 3.63	42.88 ± 3.23	**0.007***

SR: sit and rich; BYT: before yoga training; HExt: Hyperextension; RLF: right lateral flexion; LLF: left lateral flexion; Wilcoxon signed rank test.

Table 4. Balance measurement results of male and female participants before yoga training and after sessions 1, 5, and 10.

Parameters	Female (n:15) Mean ± Sd	Male (n:13) Mean ± Sd	p
Standing test			
Lons 0	4.19 ± 1.24	5.55 ± 1.52	**0.011***
Lats 0	2.23 ± 0.75	2.13 ± 0.96	0.835
Fca 0	10.23 ± 5.27	14.90 ± 9.34	0.181
Ta 0	8.30 ± 5.09	9.35 ± 7.74	0.765
Lons 1	4.53 ± 2.28	5.25 ± 2.03	0.173
Lats 1	2.33 ± 0.99	2.58 ± 1.11	0.628
Fca 1	12.02 ± 9.67	17.86 ± 14.51	0.357
Ta 1	6.69 ± 5.84	6.34 ± 3.89	0.800
Lons 5	4.31 ± 1.02	5.40 ± 1.75	0.069
Lats 5	2.24 ± 1.05	2.69 ± 1.25	0.289
Fca 5	10.90 ± 6.44	15.85 ± 7.60	0.072
Ta 5	7.55 ± 5.85	12.06 ± 11.24	0.394
Lons 10	4.74 ± 1.74	5.55 ± 2.64	0.345
Lats 10	2.51 ± 1.31	2.85 ± 1.08	0.407
Fca 10	13.70 ± 10.28	19.18 ± 16.77	0.222
Ta 10	4.85 ± 2.66	7.60 ± 5.96	0.259
Stepping test			
Ld 0	86.41 ± 31.96	67.01 ± 25.48	0.053
Latsw 0	13.31 ± 14.19	13.53 ± 10.59	0.420
Ad 0	16.87 ± 7.52	12.21 ± 8.87	0.147
Ss 0	42.67 ± 21.41	36.16 ± 24.89	0.447
Ld 1	47.74 ± 27.52	33.70 ± 14.65	0.160
Latsw 1	9.11 ± 2.47	11.12 ± 5.16	0.549
Ad 1	33.97 ± 42.39	22.69 ± 22.90	0.800
Ss 1	27.87 ± 24.75	34.35 ± 26.19	0.628
Ld 5	41.11 ± 20.06	36.18 ± 24.21	0.381
Latsw 5	9.00 ± 2.68	12.40 ± 8.42	0.381
Ad 5	23.72 ± 27.67	52.88 ± 55.25	0.112
Ss 5	23.88 ± 21.60	30.35 ± 23.11	0.345
Ld 10	35.31 ± 18.31	34.63 ± 20.89	0.645
Latsw 10	10.22 ± 3.27	10.27 ± 4.66	0.420
Ad 10	25.57 ± 25.37	32.21 ± 42.34	0.945
Ss 10	14.26 ± 9.05	28.12 ± 21.21	0.080

Lons = longitudinal sway; Lats = lateral sway; Fca = forehead covering area; Ta = torticollis angle; Ld = longitudinal deviation; Latsw = lateral sway width; Ad = angular deviation; Ss = self spin; 0= pre yoga; 1 = 1st session; 5 = 5 th session; 10 = 1th session; Mann–Whitney U test.

Table 5. Comparison of Standing Test measurement results of male and female participants between yoga training sessions.

Parameters	Female (n:15) Mean ± Sd		p	Male (n:13) Mean ± Sd		p
Lons 0-Lons 1	4.19 ± 1.24	4.53 ± 2.28	0.842	5.55 ± 1.52	5.25 ± 2.03	0.552
Lons 1-Lons 5	4.53 ± 2.28	4.31 ± 1.02	0.570	5.25 ± 2.03	5.40 ± 1.75	0.807
Lons 5-Lons 10	4.31 ± 1.02	4.74 ± 1.74	0.426	5.40 ± 1.75	5.55 ± 2.64	0.889
Lats 0-Lats 1	2.23 ± 0.75	2.33 ± 0.99	0.551	2.13 ± 0.96	2.58 ± 1.11	0.133
Lats 1-Lats 5	2.33 ± 0.99	2.24 ± 1.05	0.700	2.58 ± 1.11	2.69 ± 1.25	0.753
Lats 5-Lats 10	2.24 ± 1.05	2.51 ± 1.31	0.410	2.69 ± 1.25	2.85 ± 1.08	0.780
Fca 0-Fca 1	10.23 ± 5.27	12.02 ± 9.67	0.683	14.90 ± 9.34	17.86 ± 14.51	0.650
Fca 1-Fca 5	12.02 ± 9.67	10.90 ± 6.44	0.650	17.86 ± 14.51	15.85 ± 7.60	0.972
Fca 5-Fca 10	10.90 ± 6.44	13.70 ± 10.28	0.334	15.85 ± 7.60	19.18 ± 16.77	0.889
Ta 0-Ta 1	8.30 ± 5.09	6.69 ± 5.84	0.268	9.35 ± 7.74	6.34 ± 3.89	0.294
Ta 1-Ta 5	6.69 ± 5.84	7.55 ± 5.85	0.691	6.34 ± 3.89	12.06 ± 11.24	0.173
Ta 5- Ta 10	7.55 ± 5.85	4.85 ± 2.66	0.211	12.06 ± 11.24	7.60 ± 5.96	0.173

Lons = longitudinal sway; Lats = lateral sway; Fca = forehead covering area; Ta = torticollis angle; 0= pre yoga; 1 = 1st session; 5 = 5 th session; 10 = 1th session; Wilcoxon signed rank test.

Table 6. Comparison of Stepping Test measurement results of male and female participants between yoga training sessions.

Parameters	Female (n:15) Mean ± Sd		p	Male (n:13) Mean ± Sd		p
Ld 0-Ld 1	86.41 ± 31.96	47.74 ± 27.52	**0.003***	67.01 ± 25.48	33.70 ± 14.65	**0.005***
Ld 1-Ld 5	47.74 ± 27.52	41.11 ± 20.06	0.293	33.70 ± 14.65	36.18 ± 24.21	0.737
Ld 5-Ld 10	41.11 ± 20.06	35.31 ± 18.31	0.173	36.18 ± 24.21	34.63 ± 20.89	0.753
Lsw 0-Lsw 1	13.31 ± 14.19	9.11 ± 2.47	0.209	13.53 ± 10.59	11.12 ± 5.16	0.701
Lsw 1-Lsw 5	9.11 ± 2.47	9.00 ± 2.68	0.798	11.12 ± 5.16	12.40 ± 8.42	0.583
Lsw 5-Lsw 10	9.00 ± 2.68	10.22 ± 3.27	0.173	12.40 ± 8.42	10.27 ± 4.66	0.485
Ad 0-Ad 1	16.87 ± 7.52	33.97 ± 42.39	0.379	12.21 ± 8.87	22.69 ± 22.90	0.196
Ad 1-Ad 5	33.97 ± 42.39	23.72 ± 27.67	0.394	22.69 ± 22.90	52.88 ± 55.25	0.196
Ad 5-Ad 10	23.72 ± 27.67	25.57 ± 25.37	0.496	52.88 ± 55.25	32.21 ± 42.34	0.101
Ss 0-Ss 1	42.67 ± 21.41	27.87 ± 24.75	0.088	36.16 ± 24.89	34.35 ± 26.19	0.807
Ss 1-Ss 5	27.87 ± 24.75	23.88 ± 21.60	0.691	34.35 ± 26.19	30.35 ± 23.11	0.600
Ss 5-Ss 10	23.88 ± 21.60	14.26 ± 9.05	0.173	30.35 ± 23.11	28.12 ± 21.21	0.917

Ld = longitudinal deviation; Latsw = lateral sway width; Ad = angular deviation; Ss = self-spin; 0= pre yoga; 1 = 1st session; 5 = 5 th session; 10 = 1th session; Wilcoxon signed rank test.

Discussion

Our study showed that yoga was effective in improving flexibility among healthy young adults of both sexes, although the males showed greater improvement than females in the flexibility results. Moreover, we found that yoga training improved postural stability but a greater number of sessions did not contribute more to stability.

There was an improvement in all flexibility measurements in both sexes after training. The static stretching nature of yoga poses is well-known to increase flexibility after yoga training. The result is the same in our study, which is both expected and consistent with the literature (Lau, Yu, & Woo, 2015). The researchers in previous studies have revealed that females are more flexible than males (Cipriani et al., 2012; Danneskiold-Samsøe et al., 2009). In their study examining the trainability of flexibility according to sex, Merino-Marban et al., (2014) and Farinatti et al., (2014) showed that there was a significant and similar improvement in the stretching capacity of the hamstring and lumbar muscles of both male and female university students after a passive-static stretching session. In the same study, they found that females were more flexible than males in the V-sit and reach test (Merino-Marban et al., 2014; Farinatti et al., 2014). The greater improvement in flexibility among males after yoga training may be attributable to the males' lower initial flexibility measurements compared to females.

Some researchers have demonstrated the effect of short-term yoga training on balance in different patient groups in their studies (Ahmadi et al., 2010; Jorrakate, Kongsuk, Pongduang, Sadsee, & Chanthorn, 2015). In a study where Jorrakate, Kongsuk, Pongduang, Sadsee, and Chanthorn (2015) investigate the effect of yoga training on static and dynamic standing postural balance in obesity, participants underwent four weeks of training. The yoga training group showed improved static postural balance in the second, third and fourth weeks. In terms of dynamic postural balance, the authors detected significant improvement was observed at the end of week four in the yoga training group compared with the control group. These findings were attributed to the more complicated strategy required by dynamic standing balance than by static postural control. The control group showed no significant improvements in static or dynamic balance. In the present study, we observed comparable postural stability in both groups after the first session of the yoga training. Dynamic stability improved in both groups with the first session and then reached a plateau. Our findings indicated that in healthy individuals, yoga training contributed to postural stability after a single session but a greater number of sessions did not contribute further to the increased stability.

There are considerably fewer studies investigating the effect of yoga training on balance and posture in healthy individuals (Mondal et al., 2017) compared to the number of studies evaluating its effect on patient groups (Ahmadi et al., 2010). Hewett et al. (2015) concluded that research on the acute effects of yoga practice will increase our understanding of physiological adaptation and provide guidance on how yoga practice can serve as a tool to increase balance in healthy young individuals. Schmid et al. (2012) showed in their study that asana-oriented short-term yoga training can effectively increase young adults' static stability.

With the Covid-19 pandemic, activities such as yoga that do not require any equipment and that can be done individually have been a more important part of our lives. Studies have underlined the effectiveness of yoga practices, including meditation, in maintaining homeostasis in non-communicable diseases by reducing stress levels and promoting a healthy lifestyle. Comprehensive studies have also emphasized that personalized yoga programs can prevent and/or mitigate viral infection by providing a broad-spectrum immunity in the body (Nagendra, 2020). In a study examining the effect of daily yoga classes on elderly women (Pandya, 2021), the researcher determined that this training was effective in reducing fears and anxieties of COVID-19 and promoting resilience and vitality among older women living in the community. In addition, the COVID-19 pandemic reveals the consequences of falls, which are associated with worsening physical functioning (Hoffman et al., 2022) and postural instability. In this context, there is a need to implement individualized yoga programs that have an effect on physical parameters such as postural stability.

Although the researchers explained the tests of postural stability verbally to the participants, they also made a demonstration of the test for them. The participants did not do any practice trials before the test. In other words we did not perform enough pre-measurements to quantitatively assess whether the subjects had learned the test well. The researchers recorded the first numerical data obtained for each participant as the first measurement. Therefore, it cannot be clearly distinguished whether improvements in postural stability obtained at the end of the first session were due to the learning curve (Keklicek, Kırdı, Yalcin, Yuce, & Topuz, 2019; Wrisley et al., 2007) or due to the effect of yoga. This limitation of the present study weakens the generalizability of the study results.

Conclusions

The researchers of this study demonstrated that yoga is effective in improving flexibility and postural stability in healthy young adults and that improvement in flexibility is greater in males compared to females. Therefore, the researchers recommend follow-up studies in larger populations to investigate whether yoga has long-term effects on flexibility and postural stability.

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The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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References

Ahmadi, A., Nikbakh, M., Arastoo, A., & Habibi, A. H., (2010). The effects of a yoga intervention on balance, speed and endurance of walking, fatigue and quality of life in people with multiple sclerosis. *Journal of Human Kinetics 23*(2010), 71–78. https://doi.org/10.2478/v10078-010-0009-2

Ansdell, P., Thomas, K., Hicks, K. M., Hunter, S. K., Howatson, G., & Goodall, S. J. E. p. (2020). Physiological sex differences affect the integrative response to exercise: acute and chronic implications. *Experimental Physiology 105*(12), 2007–2021. https://doi.org/10.1113/EP088548

Chiari, L., Rocchi, L., & Cappello, A. J. C. B. (2002). Stabilometric parameters are affected by anthropometry and foot placement. *Clinical Biomechanics (Bristol, Avon) 17*(9–10), 666–677.

Cigali, B. S., Uluçam, E., & Bozer, C. J. B. M. J. (2011). 3D motion analysis of hip, knee and ankle joints of children aged between 7–11 years during. *Gait 2011*(2), 197–201.

Cipriani, D. J., Terry, M. E., Haines, M. A., Tabibnia, A. P., & Lyssanova, O. J. T. (2012). Effect of stretch frequency and sex on the rate of gain and rate of loss in muscle flexibility during A hamstring-stretching program: A randomized single-blind longitudinal study. *Journal of Strength and Conditioning Research 26*(8), 2119–2129. https://doi.org/10.1519/JSC.0b013e31823b862a

Danneskiold-Samsøe, B., Bartels, E. M., Bülow, P. M., Lund, H., Stockmarr, A., Holm, C. C., Wätjen, I., Appleyard, M., & Bliddal, H. (2009). Isokinetic and isometric muscle strength in a healthy population with special reference to age and gender. *Acta Physiologica 197*, 1–68. https://doi.org/10.1111/j.1748-1716.2009.02022.x

de Haart, M., Geurts, A. C., Huidekoper, S. C., Fasotti, L., & van Limbeek, J. J. (2004). Recovery of standing balance in postacute stroke patients: a rehabilitation cohort study. *Archives of Physical Medicine and Rehabilitation 85*(6), 886–895. https://doi.org/10.1016/j.apmr.2003.05.012

Diamond, L. (2012). The benefits of yoga in improving health. *Primary Health Care22*(2), 16–19.

Farinatti, P., Rubini, E., Silva, E., & Vanfraechem, J. J. I. (2014). Flexibility of the elderly after one-year practice of yoga and calisthenics. *International Journal of Yoga Therapy 24*(1), 71–77.

Fomin, Å., Ahlstrand, M., Schill, H. G., Lund, L. H., Ståhlberg, M., Manouras, A., & Gabrielsen, A. J. B. p. (2012). Sex differences in response to maximal exercise stress test in trained adolescents. *BMC Pediatrics 12*(1), 1–8. https://doi.org/10.1186/1471-2431-12-127

Golding, L. A. J. A. s H., & Journal, F. (1997). Flexibility, stretching, and flexibility testing recommendations for testing and standards. *ACSM'S Health & Fitness Journal 1*(2), 17–20.

Hazelhurst, L. T., & Claassen, N. (2006). Gender differences in the sweat response during spinning exercise. *Journal of Strength and Conditioning Research 20*(3), 723–724.

Hewett, T. E., Myer, G. D., Ford, K. R., Heidt, R. S., Jr, Colosimo, A. J., McLean, S. G., Van den Bogert, A. J., Paterno, M. V., & Succop, P. J. T. A. (2005). Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: A prospective study. *The American Journal of Sports Medicine 33*(4), 492–501. https://doi.org/10.1177/0363546504269591

Hoffman, G. J., Malani, P. N., Solway, E., Kirch, M., Singer, D. C., & Kullgren, J. T. J. J. (2022). Changes in activity levels, physical functioning, and fall risk during the COVID-19 pandemic. *Journal of the American Geriatrics Society 70*(1), 49–59. https://doi.org/10.1111/jgs.17477

Hunter, S. K. J. M. (2016). The relevance of sex differences in performance fatigability. *Medicine and Science in Sports and Exercise 48*(11), 2247–2256. https://doi.org/10.1249/MSS.0000000000000928

Jorrakate, C., Kongsuk, J., Pongduang, C., Sadsee, B., & Chanthorn. (2015). Effect of yoga training on one leg standing and functional reach tests in obese individuals with poor postural control. *Journal of Physical Therapy Science 27*(1), 59–62. https://doi.org/10.1589/jpts.27.59

Hewett, Z. L., Cheema, B. S., Pumpa, K. L., & Smith, C. A. (2015). The effects of Bikram yoga on health: critical review and clinical trial recommendations. *Evidence-Based Complementary and Alternative Medicine 2015*, 1–13. https://doi.org/10.1155/2015/428427

Keklicek, H., Kırdı, E., Yalcin, A., Yuce, D., & Topuz, S. J. J. (2019). Learning effect of dynamic postural stability evaluation system. *Journal of Back and Musculoskeletal Rehabilitation 32*(1), 7–14. https://doi.org/10.3233/BMR-181172

Kwon, R., Kasper, K., London, S., & Haas, D. M. (2020). A systematic review: The effects of yoga on pregnancy. *European Journal of Obstetrics, Gynecology, and Reproductive Biology 250*, 171–177. https://doi.org/10.1016/j.ejogrb.2020.03.044

Lau, C., Yu, R., & Woo, J. J. (2015). Effects of a 12-week hatha yoga intervention on cardiorespiratory endurance, muscular strength and endurance, and flexibility in Hong Kong Chinese adults: A controlled clinical trial. *Evidence-Based Complementary and Alternative Medicine 2015*, 1–12. https://doi.org/10.1155/2015/958727

Lynton, H., Kligler, B., & Shiflett, S. J. T. (2007). Yoga in stroke rehabilitation: A systematic review and results of a pilot study. *Topics in Stroke rehabilitation 14*(4), 1–8. https://doi.org/10.1310/tsr1404-1

Magalhaes, J., Ascensao, A., & Soares, J. J. J. (2004). Concentric quadriceps and hamstrings isokinetic strength in volleyball and soccer players. *The Journal of Sports Medicine and Physical Fitness 44*, 119–125.

Marongiu, E., & Crisafulli, A. J. S. S. (2015). Gender differences in cardiovascular functions during exercise: A brief review. *Sport Sciences for Health 11*(3), 235–241. https://doi.org/10.1007/s11332-015-0237-x

Merino-Marban, R., Romano, D. P., & Mayorga-Vega, D. J. C. (2014). Influence of sex on the acute effect of stretching on V sit-and-reach scores in university students. *Central European Journal of Sport Sciences and Medicine6*(2), 13–19. https://wnus.edu.pl/cejssm/en/issue/24/article/127/

Miller, A. E. J., MacDougall, J., Tarnopolsky, M., & Sale, D. J. E. (1993). Gender differences in strength and muscle fiber characteristics. *European Journal of Applied Physiology and Occupational Physiology66*(3), 254–262. https://doi.org/10.1007/BF00235103

Mondal, K., Majumdar, D., Pramanik, A., Chatterjee, S., Darmora, M., & Majumdar, D. J. I. J. o C. M. (2017). Application of yoga as an effective tool for improving postural balance in healthy young Indian adults. *International Journal of Chinese Medicine 1*(2), 62–69. https://doi.org/10.11648/j.ijcm.20170102.14

Morioka, S., Hiyamizu, M., & Yagi, F. J. J. (2005). The effects of an attentional demand tasks on standing posture control. *Journal of Physiological Anthropology and Applied Human Science 24*(3), 215–219. https://doi.org/10.2114/jpa.24.215

Nagendra, H. J. I. (2020). Yoga for COVID-19. *International Journal of Yoga 13*(2), 87–88. https://doi.org/10.4103/ijoy.IJOY_27_20

Nejc, S., Jernej, R., Loefler, S., & Kern, H. J. J. (2010). Sensitivity of body sway parameters during quiet standing to manipulation of support surface size. *Journal of Sports Science & Medicine 9*(3), 431–438.

Östh, J., Diwan, V., Jirwe, M., Diwan, V., Choudhary, A., Mahadik, V. K., Pascoe, M., & Hallgren, M. J. B. (2019). Effects of yoga on well-being and healthy ageing: Study protocol for a randomised controlled trial (FitForAge). *BMJ Open 9*(5), e027386. https://doi.org/10.1136/bmjopen-2018-027386

Pandya, S. P. (2021). Older women and wellbeing through the pandemic: Examining the effect of daily online yoga lessons. *Health Care for Women International 42*(11), 1255–1278. https://doi.org/10.1080/07399332.2021.1932897

Schmid, A. A., Van Puymbroeck, M., Altenburger, P. A., Schalk, N. L., Dierks, T. A., Miller, K. K., Damush, T. M., Bravata, D. M., & Williams, L. S. (2012). Poststroke balance improves with yoga: A pilot study. *Stroke 43*(9), 2402–2407. https://doi.org/10.1161/STROKEAHA.112.658211

Shashikiran, H., Shetty, S., Shetty, P., & Kumar, C. J. I. (2015). A study on influence of yoga on autonomic variables on young adults. *International Journal of Innovative Research and Development4*(2), 267–274. http://www.internationaljournalcorner.com/index.php/ijird_ojs/article/view/135462

Sheel, A. W. (2016). *Sex differences in the physiology of exercise: An integrative perspective*. Wiley Online Library.

Shetty, S., Subramanya, P., & Moorthy, V. K. (2018). Effect of yoga on flexibility and psychomotor performance in college-going healthy individuals. *International Journal of Yoga - Philosophy, Psychology and Parapsychology 6*(1), 51–54. https://doi.org/10.4103/ijny.ijoyppp_36_17

Siedentopf, F., Utz-Billing, I., Gairing, S., Schoenegg, W., Kentenich, H., & Kollak, I. J. G. u F. (2013). Yoga for patients with early breast cancer and its impact on quality of life – A randomized controlled trial. *Geburtshilfe Und Frauenheilkunde 73*(4), 311–317.

Subramaniam, S., & Bhatt, T. J. C. (2017). Effect of yoga practice on reducing cognitive-motor interference for improving dynamic balance control in healthy adults. *Complementary Therapies in Medicine 30*, 30–35. https://doi.org/10.1016/j.ctim.2016.10.012

WHO. (2021). http://www.emro.who.int/about-who/public-health-functions/health-promotion-disease-prevention.html

WHO: Coronavirus disease (COVID-19) pandemic. (n.d.) https://www.who.int/teams/health-financing/covid-19

WHO: Strengthening the health system response to COVID-19. (n.d.) https://www.euro.who.int/en/health-topics/Health-systems/pages/strengthening-the-health-system-response-to-covid-19/strengthening-the-health-system-response-to-covid-19-policy-brief

WHO:Physical-activity. (n.d.) https://www.who.int/health-topics/physical-activity#tab=tab_1

WHO: Body Mass Index. (n.d.) https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi

Wren, A. A., Wright, M. A., Carson, J. W., & Keefe, F. J. J. P. (2011). Yoga for persistent pain: new findings and directions for an ancient practice. *Pain 152*(3), 477–480. https://doi.org/10.1016/j.pain.2010.11.017

Wrisley, D. M., Stephens, M. J., Mosley, S., Wojnowski, A., Duffy, J., & Burkard, R. J. A. (2007). Learning effects of repetitive administrations of the sensory organization test in healthy young adults. *Archives of Physical Medicine and Rehabilitation88*(8), 1049–1054. https://doi.org/10.1016/j.apmr.2007.05.003