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A comparative study of slow and fast suryanamaskar on physiological function

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ABSTRACT

Background: Numerous scientific studies have reported beneficial physiological changes after short- and long-term yoga training. Suryanamaskar (SN) is an integral part of modern yoga training and may be performed either in a slow or rapid manner. As there are few studies on SN, we conducted this study to determine the differential effect of 6 months training in the fast and slow versions.

Materials and Methods: 42 school children in the age group of 12–16 years were randomly divided into two groups of 21 each. Group I and Group II received 6 months training in performance of slow suryanamaskar (SSN) and fast suryanamaskar (FSN), respectively.

Results: Training in SSN produced a significant decrease in diastolic pressure. In contrast, training in FSN produced a significant increase in systolic pressure. Although there was a highly significant increase in isometric hand grip (IHG) strength and hand grip endurance (HGE) in both the groups, the increase in HGE in FSN group was significantly more than in SSN group. Pulmonary function tests showed improvements in both the groups though intergroup comparison showed no significance difference. Maximum inspiratory pressure (MIP) and maximum expiratory pressure increased significantly in both the groups with increase of MIP in FSN group being more significant than in SSN.

Conclusion: The present study reports that SN has positive physiological benefits as evidenced by improvement of pulmonary function, respiratory pressures, hand grip strength and endurance, and resting cardiovascular parameters. It also demonstrates the differences between SN training when performed in a slow and fast manner, concluding that the effects of FSN are similar to physical aerobic exercises, whereas the effects of SSN are similar to those of yoga training.

Key words: Physical aerobic exercise; suryanamaskar; yoga training.

INTRODUCTION

Suryanamaskar (SN) is a sequential combination of yogic postures performed dynamically in synchrony with the breath. Although there are a number of reports on the effect of yoga training on pulmonary functions,[1,2] respiratory pressures,[3,4] handgrip strength and endurance,[3-7] and cardiovascular parameters,[8-10] scientific literature is deficient on the physiological effects of SN that is an integral part of modern yoga training. For many years, there was only one scientific study[11] on this practice and even that study was performed on only two subjects. In recent times, studies have been conducted by Sinha and colleagues[12] who studied energy cost and cardiorespiratory changes during the practice, as well as Bhutkar and colleagues[13] who conducted a pilot study on 6 months of SN practice on cardiorespiratory fitness parameters. Sinha and colleagues had concluded that SN is an ideal form of aerobic exercise having static, stretching and dynamic muscular movements involving all major joints.[12]

Various schools of yoga differ in the practice of SN. Some
schools advocate performance in a slow manner in tune with slow breathing, while others advocate a rapid method of performing multiple rounds in a fast manner similar to physical exercise. It has been suggested that SN at different speeds provides different benefits and that when it is done rapidly it warms up the body and acts as a cardio tonic, whereas when done slowly it strengthens and tones the musculature and enhances functioning of internal organs.\(^{14}\) It has also been suggested that one can drive away depression through fast rounds or cool down hyperactivity with slow rounds.\(^{15}\)

This study was planned based on our hypothesis that these two methods of performance based on different speeds would have different physiological effects.

The objectives of this study were:
1. to determine the effect of SN on pulmonary function, respiratory pressures, handgrip strength and endurance and resting cardiovascular parameters and
2. to compare the effects of 6 months training in slow suryanamaskar (SSN) and fast suryanamaskar (FSN).

**MATERIALS AND METHODS**

**Subjects**

Forty-two healthy student volunteers (21 males and 21 females) studying 8th standard at Government Higher Secondary School, Indira Nagar, Pondicherry, were recruited. Subjects with history of active sports training, previous experience of yoga training, history of major medical illness such as tuberculosis, hypertension, diabetes mellitus, bronchial asthma in the past and history of major surgery in the recent past were excluded from the study. The mean age of the subjects was \(13.45 \pm 0.18\) years, mean height \(1.47 \pm 0.01\) m, mean weight \(34.79 \pm 1.34\) kg and mean body mass index (BMI) was \(15.89 \pm 0.42\) units. They were briefed about the study and informed consent was obtained from them along with permission from their parents and head of the institution. This study was conducted within the purview of a larger study on the physiological effects of yoga, and ethical approval was obtained from institutional ethics committee for the entire study.

**Training schedule**

Subjects of either gender were randomly divided into the two groups of 21 (10 girls and 11 boys) each and trained to perform SN by a qualified instructor. SN consists of a sequence of 12 postures performed in a rhythmic manner starting in an upright standing position and then moving into alternate forward and backward bending movements interspaced with movements involving all four limbs before ending the practice in an erect standing position.\(^{16,17}\)

**Group I (FSN group)**

The subjects were trained to perform SN in a rapid manner so that all 12 postures were completed in 2 minutes. Fifteen rounds were performed in 30–40 minutes. After 2 weeks of training, they practiced the same under direct supervision of the instructor for a total duration of 6 months.

**Group II (SSN group)**

The subjects were trained to perform SN in a slow manner so that each of the 12 postures was held for 30 seconds. Each round took 6 minutes to complete and five rounds were performed in 30–40 minutes. After 2 weeks of training, they practiced the same under direct supervision of the instructor for a total duration of 6 months.

Two to three days before the actual recording, the subjects were familiarized with the laboratory environment and their anthropometric measurements were taken. On the day of the test, subjects reported at our polygraph laboratory 2 hours after a light breakfast. Recordings were taken at laboratory temperature of \(27 \pm 1^\circ\)C.

**Parameters**

**Hand grip strength and endurance**

Isometric hand grip strength (IHG) was measured with the dominant hand gripping the inflated cuff of a mercury manometer while the subject was sitting comfortably in a chair. The arm was extended in front at the shoulder level and kept horizontal to the ground. Endurance time for 33% of IHG was calculated as the duration for which 33% of IHG could be sustained and noted as hand grip endurance (HGE).

**Respiratory pressures**

Maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) were recored as follows. MIP was determined by asking the subject to perform maximum inspiratory effort against the mercury column of a manometer after breathing out fully. The maximum level at which the mercury column could be maintained for about 3 seconds was noted. MEP was determined by asking the subject to blow against the mercury column after taking in a full breath. MEP that could be maintained for about 3 seconds was noted. It was ensured that the subjects did not use oral muscles to develop pressure or use their tongue to block the tubing.

**Pulmonary function tests**

Forced vital capacity (FVC), forced expiratory volume in 1st
second (FEV₁), and peak expiratory flow rate (PEFR) were measured using a computerized spirometer (Spirocheck, Morgan, England). The subject was instructed to take maximum inspiration and blow into the mouthpiece as rapidly, forcefully and completely as possible. It was ensured that a tight seal was maintained between the lips and the mouthpiece of the spirometer.

**Resting cardiovascular parameters**

After 10 minutes of supine rest, right brachial systolic (SP) and diastolic (DP) blood pressure as well as heart rate (HR) were recorded with non-invasive semi-automatic blood pressure (BP) monitor (Press-Mate BP 8800, Colin Corporation, Komaki, Japan). Pulse pressure (PP = SP – DP), mean pressure [MP = DP + PP/3], rate pressure product [RPP = (HR × SP)/100] and double product (Do P = HR × MP) were calculated for each recording. Three BP and HR recordings at 1-minute intervals were taken and the lowest of these values was included for the present study.

The above-mentioned parameters were measured before and after the 6-month study period in both the groups. For each parameter, three trials at 3-minute intervals were given and highest of the three values was used for statistical analysis.

**Analysis of data**

In both the groups, all the above parameters were measured at the beginning and again at the end of the 6-month study period. The data were assessed for normality using GraphPad InStat and passed normality testing by Kolmogorov–Smirnov Test. The data were then analyzed using Student’s (paired) t test to compare pre- and post-training values of each group. Student’s (unpaired) t test was used to compare the values between the groups before and after training. A P value of less than 0.05 was accepted as indicating significant difference between the compared values.

**RESULTS**

The results are given in Table 1. Both the groups were comparable before training as no statistically significant difference was found between them with respect to baseline data of all parameters. The post-training analysis revealed the following findings. SSN training produced a significant (P < 0.001) increase in IHG, HGE, MIP, MEP and PEFR, along with a significant (P < 0.01) increase in FVC and FEV₁. There was also a significant (P < 0.05) fall in DP and rise in PP following SSN training along with an appreciable, yet statistically insignificant, fall in HR, MP, RPP and Do P.

It was found that FSN training also produced a significant (P < 0.001) increase in IHG, HGE, MIP and PEFR, along with a significant (P < 0.01) increase in FVC and FEV₁. There was a substantial, though statistically insignificant, increase in MEP. There was a significant (P < 0.05) rise in SP following 6 months training in FSN group, along with an appreciable, yet statistically insignificant, rise in DP, MP, PP, RPP and Do P.

Intergroup comparisons showed no statistically significant difference between the groups with respect to pre-training baseline values. Post-training analysis showed that changes in all the parameters were statistically comparable between FSN and SSN groups, except in the case of HGE and MIP that had a statistically significant (P < 0.05) rise in the FSN group as compared to the SSN group.

<table>
<thead>
<tr>
<th></th>
<th>SSN (n = 21)</th>
<th>FSN (n = 21)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IHG (mm Hg)</strong></td>
<td>122.25 ± 6.29</td>
<td>144.25 ± 5.92***</td>
</tr>
<tr>
<td></td>
<td>± 5.92***</td>
<td>± 7.48 ± 1.67</td>
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<tr>
<td><strong>HGE (seconds)</strong></td>
<td>41.65 ± 3.20</td>
<td>54.10 ± 4.10**</td>
</tr>
<tr>
<td></td>
<td>± 4.10**</td>
<td>± 3.52 ± 1.67</td>
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<tr>
<td><strong>MIP (mm Hg)</strong></td>
<td>34.05 ± 1.57</td>
<td>37.50 ± 2.57**</td>
</tr>
<tr>
<td></td>
<td>± 1.57 ± 2.91***</td>
<td>± 2.65 ± 1.35***</td>
</tr>
<tr>
<td><strong>MEP (mm Hg)</strong></td>
<td>6.65 ± 1.57</td>
<td>2.05 ± 2.00**</td>
</tr>
<tr>
<td></td>
<td>± 2.91***</td>
<td>± 2.65 ± 1.35***</td>
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<tr>
<td><strong>FVC (L)</strong></td>
<td>1.88 ± 0.08</td>
<td>2.05 ± 0.08**</td>
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<tr>
<td></td>
<td>± 0.08 ± 0.99**</td>
<td>± 0.11 ± 0.10***</td>
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<tr>
<td><strong>FEV₁ (L)</strong></td>
<td>1.84 ± 0.08</td>
<td>2.00 ± 0.08**</td>
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<tr>
<td></td>
<td>± 0.08 ± 0.99**</td>
<td>± 0.11 ± 0.10***</td>
</tr>
<tr>
<td><strong>PEFR (L/min)</strong></td>
<td>268.55 ± 14.45</td>
<td>307.20 ± 14.59</td>
</tr>
<tr>
<td></td>
<td>± 12.36***</td>
<td>± 12.28 ± 13.00***</td>
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<tr>
<td><strong>HR (beats/min)</strong></td>
<td>86.15 ± 2.38</td>
<td>82.35 ± 2.38</td>
</tr>
<tr>
<td></td>
<td>± 2.38 ± 2.08</td>
<td>± 2.52 ± 2.67</td>
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<tr>
<td><strong>SP (mm Hg)</strong></td>
<td>100.20 ± 1.57</td>
<td>101.20 ± 1.57</td>
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<td></td>
<td>± 1.57 ± 2.98</td>
<td>± 2.16 ± 2.64**</td>
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<tr>
<td><strong>DP (mm Hg)</strong></td>
<td>66.15 ± 1.84</td>
<td>61.10 ± 1.25*</td>
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<td></td>
<td>± 1.84 ± 1.25*</td>
<td>± 1.84 ± 1.83</td>
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<tr>
<td><strong>MP (mm Hg)</strong></td>
<td>77.50 ± 1.57</td>
<td>74.47 ± 1.65</td>
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<td></td>
<td>± 1.57 ± 1.65</td>
<td>± 1.82 ± 1.89</td>
</tr>
<tr>
<td><strong>PP (mm Hg)</strong></td>
<td>34.05 ± 1.67</td>
<td>40.10 ± 2.41*</td>
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<td></td>
<td>± 1.67 ± 2.41*</td>
<td>± 1.48 ± 2.11</td>
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<tr>
<td><strong>RPP (units)</strong></td>
<td>86.48 ± 3.17</td>
<td>83.52 ± 3.71</td>
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<td></td>
<td>± 3.17 ± 3.35</td>
<td>± 2.47 ± 2.97</td>
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<td><strong>Do P (units)</strong></td>
<td>6663.60 ± 215.99</td>
<td>6145.72 ± 224.05***</td>
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<tr>
<td></td>
<td>± 224.05 ± 220.25***</td>
<td>± 220.25 ± 206.63***</td>
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</table>

Values are Mean ± SEM for 21 subjects in each group; *P < 0.05, **P < 0.01, ***P < 0.001 paired "t" test between post- and pre-training values; †P < 0.05 unpaired "t" test between SSN and FSN.
An interesting difference between the groups in the post-training analysis, which was apparent but not statistically significant, was the fall in cardiovascular parameters such as DP, MP, RPP, DoP in SSN group with a converse rise in the same parameters in FSN.

**DISCUSSION**

**Isometric handgrip strength and endurance**

There was a statistically significant increase \((P < 0.001)\) in IHG and HGE in both the groups. The increase in FSN was significant \((P < 0.05)\) as compared to the increase in SSN group. Our results are similar to those of previous studies on yoga that have reported an increase in hand grip strength following yoga training.\(^{[5,6]}\) In earlier works from our laboratories, we have found a significant increase in IHG and HGE time after 3 months of yoga training.\(^{[3,4]}\) This increase in muscle strength and endurance time can be explained on the basis of stimulation of skeletal muscles during the isometric contraction maintained during the steady state of the different postures in SN. This may be also because of the delayed onset in muscular fatigue. Our study gives evidence that both SSN and FSN improve muscle strength like yoga practices and that it is more apparent in the case of FSN.

**Respiratory pressures**

MIP increased significantly in both FSN and SSN groups \((P < 0.001)\) and this increase in FSN group was more significant \((P < 0.05)\) as compared to that in SSN group. MEP increased significantly in SSN group \((P < 0.001)\). This increase in MIP and MEP after SN training is similar to our earlier observations that yoga training increases MIP and MEP.\(^{[5,6]}\) This suggests that SN training improves the strength of both expiratory and inspiratory muscles. The different postures of SN involve isometric contraction and chest wall expansion which may be improving strength of the intercostal muscles.

Maximum respiratory pressures are simple, yet specific, indices of respiratory muscle strength and highest MIP is obtained at lung volumes of less than 50% of total lung capacity and highest MEP is obtained at lung volumes of more than 70% of total lung capacity.\(^{[17,18]}\) Earlier studies from our laboratory have reported improvement in the strength of inspiratory and as well expiratory muscles following yoga training.\(^{[3]}\) In the present study, SSN produced a significant improvement in both MIP and MEP while FSN had a significant effect only on MIP though a statistically insignificant yet appreciable increase in MEP was noted. Intergroup comparison showed that FSN has a more significant effect on MIP than on MEP. This can be attributed to the pattern of breathing and type of SN practiced. It is plausible that the slow and controlled inspiration and expiration, as practiced in SSN, contributed to significant increase in both pressures, whereas FSN, being performed rapidly, had no such controlled expiration phase and hence resulted in increase in MIP alone.

**Pulmonary functions**

FVC and FEV\(_1\) increased significantly \((P < 0.001)\) in both FSN and SSN groups. PEFR also increased significantly in both the groups, the increase being statistically significant \((P < 0.001)\). Bhutkar and colleagues have reported an increase in MVV and FEV\(_1\) following 6 months of SN training and practice.\(^{[13]}\)

In our study, there was a significant improvement in FVC, FEV\(_1\), and PEFR. This is similar to earlier studies on yoga that have reported significant improvement in vital capacity (VC), FVC, FEV\(_1\), and PEFR following training.\(^{[2,19,20]}\) This can be attributed to the increase in the strength of the major respiratory muscles following SN practice. It is important to note that in spite of differences in the method of performance, both FSN and SSN have produced similar results. On the basis of this study, SN may be recommended for improving respiratory function in children and adolescents.

**Resting cardiovascular parameters**

Resting HR decreased in both the groups, and though this was statistically insignificant, it was more apparent in SSN. Six-month practice of FSN produced a significant increase in SP and relatively no change in either HR or DP. FSN is a fast rhythmic sequential performance of various postures and all the large muscle groups are subjected to rhythmic contraction and relaxation, which is analogous to any exercise involving large muscle groups. This may be bringing about increase in venous return causing rise in stroke volume and SP. The increase in SP in FSN group can be thus attributed to adaptive physiological changes and this is consistent with the report of Udupa and colleagues which showed a fall in HR and rise in SP following SN training.\(^{[11]}\) It is possible that the SN done by their subjects was of the FSN variety but this is not clear from their paper.

The DP was significantly lower in SSN group at the end of training period. The main determinant of DP is peripheral vascular resistance/tone, which is modulated by sympathetic tone. An earlier study from our laboratory has shown that 3 months of pranayam training modulates ventricular performance by increasing parasympathetic activity and decreasing sympathetic activity as evidenced by changes in systolic time intervals.\(^{[21]}\) The SN study by Bhutkar and colleagues reported a fall in both SP and DP after 6 months of training and practice.\(^{[13]}\) In our study, the significant decrease of DP and statistically insignificant
5% decrease in resting heart rate in SSN group may be attributed to a decrease in peripheral resistance due to decrease in sympathetic tone. These changes evidenced in our study also contributed to the significant increase in pulse pressure among SSN subjects, indicating better tissue perfusion.

RPP and Do P are indirect measures of cardiac oxygen consumption and work done by the heart and both showed a trend of increase in FSN and decrease in SSN. This implies that the practice of FSN and SSN for a period of 6 months may increase and decrease resting cardiac oxygen consumption, respectively. In their study, Bhutkar and colleagues reported an increase in VO2 max, indicating improved aerobic capacity after training in SN.[11] An earlier study on the component steps of the SN had also concluded that SN exerts only a moderate stress on the cardiorespiratory system as it keeps the practitioner within their lactate and anaerobic threshold.[12]

One of the interesting differences which was apparent but not statistically significant between the groups in the post-training analysis was the fall in cardiovascular parameters such as DP, MP RPP, Do P in SSN group with a converse rise in the same parameters in FSN. This may be understood as being a result of a more relaxed state of mind leading to a decrease in peripheral resistance due to decrease in sympathetic tone as illustrated by fall in DP and MP coupled with a reduced load on the heart as illustrated by changes in RPP and Do P.

CONCLUSION

The present study shows that SN has positive physiological benefits as evidenced by changes in pulmonary function, respiratory pressures, handgrip strength and endurance, and resting cardiovascular parameters. It also demonstrates the comparative differential effects of training in SN when done in a slow and fast manner. The effects of FSN are similar to those of physical aerobic exercise with increased muscular endurance and power, whereas the effects of SSN are similar to those of Yoga training with fall in cardiovascular parameters toward lower normal values. On the basis of the present study it is recommended that SN be introduced to school children to improve their physical fitness.

The strength of this study is that it is the first study comparing physiological effects of 6 months training and performance of SN in a slow and fast manner. Even though earlier studies have been carried out on SN, they have been done either in combination other yoga practices[20] with very few subjects[11] or have only focused on acute effects of individual postures.[12] The only study that has actually dealt with SN training over a long period is the pilot study done by Bhutkar et al.[13] They had however not given adequate description of the type of SN used in the training and both these studies (our study as well as their study) suffer a lack of a control group. Further studies with control group and in different age groups can help us understand the inherent mechanisms resulting in such differential beneficial effects.

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