Section IX

Cardiorespiratory parameters in Surya Namaskar: a comparison between Yoga trainees and Yoga Proficient
9. Cardiorespiratory parameters in *Surya Namaskar*: a comparison between Yoga trainees and Yoga Proficient

9.1 Introduction

*Surya Namaskar* is considered as the most dynamic group of Yogic Asanas. The performance of *Surya Namaskar* involves flexion, extension, abduction and adduction of many muscles and joints of the body and it also involves stretching of muscles on the back, thigh and abdomen. The effect of training on cardiorespiratory system has been studied in an ample number of scientific papers (3, 31, 34, 44-45, 67, 74, 77, 83, 95, 97, 103, 107-108, 118, 123, 129, 178, 185, 200, 202, 209, 223, 231, 234). One of the studies by our laboratory had revealed that cardiovascular system gets conditioned faster than other system in the yoga trainees. Subsequently the respiratory and metabolic parameters get conditioned during the advanced period of training session (207).

In an order to observe the degree of conditioning achieved in different cardiorespiratory parameters during the practice of *Surya Namaskar*, the yoga trainees were compared with the Proficient who were practicing yoga for more than four years and with Semi-Proficient who practiced Yoga for 2-4 years.

9.2 Aim

The present study is aimed to observe -

9.2.1. The cardiorespiratory changes during the practice of SN by Proficient and Semi-Proficient.

9.2.2. The degree of cardiorespiratory conditioning as achieved by Proficient and Semi-Proficient were compared with the Yoga trainees.

9.3 Material and methods

20 healthy subjects amongst a group of male yoga instructors were
chosen for the present study. 10 subjects were put in yoga Proficient group and remaining 10 were put in Semi-Proficient group. These subjects were categorised into two groups based on the proficiency of practicing various yogic practices including SN. Their age, height and body weight are given in the fourth section (Table 1). Subjects were explained in detail about the study protocol both in Hindi as well as in English language. Since the yoga proficient and Semi-Proficient are advanced level of yoga practitioner they used to perform one round of SN in shorter period of time (unlike protocol as followed by this study for practicing SN). However they were requested to follow the same time duration for practicing one round of SN as our trainees did. All the cardiorespiratory parameters as recorded in trainees were being monitored continuously (as given in general methodology of section 4) during the practice of SN both in the Proficient and Semi-Proficient subjects. After recording the different parameters it was then compared with the different phases for the trainees’ data.

Statistical analysis of the data was done by using two- way ‘ANOVA’ (without replication) for intragroup comparison whereas for intergroup comparison unpaired t-test was applied in Microsoft excel software programme.

9.4 Result

Values of the different cardiorespiratory parameters as recorded in 12 postures during the performance of SN by Proficient and Semi-Proficient were graphically shown from the Figure 46 to Figure 55. Improvement due to training of different cardiorespiratory parameters of trainees as compared with the Proficient and were given in the Table 19.

9.4.1 Changes in VO₂

VO₂ was highest in the 11th posture and lowest in 2nd posture in case of Proficient. In case of Semi-Proficient it was found highest in 7th posture and lowest in 1st posture. VO₂ did not show any significant difference between Proficient and Semi-Proficient in any of the twelve postures in the present study.
9.4.2 Changes in HR

HR was recorded highest in the 5th posture and lowest in 3rd posture in case of proficient and it was highest in the 7th posture and lowest in the 3rd posture in case of Semi-Proficient. HR did not show any significant difference between Proficient and Semi-Proficient.

9.4.3 Changes in \(O_2P\)

\(O_2P\) was found highest in the 11th posture and was lowest in the 2nd posture in case of proficient and \(O_2P\) was found highest in 7th posture and lowest in the 1st posture in case of Semi-Proficient. \(O_2P\) did not show any significant difference between Proficient and Semi-Proficient in any of the twelve postures in SN.

9.4.4 Changes in \(f_R\)

\(f_R\) was highest in 11th posture and lowest in 2nd posture in case of Proficient as well as in Semi-Proficient. \(f_R\) significantly differed between Proficient and Semi-Proficient in 3rd, 4th and 12th posture, all being significant at \(P<0.05\) level.

9.4.5 Changes in \(V_T\)

\(V_T\) was highest in 7th posture and lowest in 3rd posture in case of Proficient and it was highest in 8th posture and lowest in 1st posture in case of Semi-Proficient. \(V_T\) differed significantly between Proficient and Semi-Proficient in 9th posture (\(P<0.05\)).

9.4.6 Changes in \(V_E\)

Proficient showed highest \(V_E\) in 11th posture and lowest \(V_E\) in 2nd posture. Semi-Proficient showed highest \(V_E\) in 11th posture and lowest in 3rd posture. \(V_E\) differed significantly between Proficient and Semi-Proficient in 3rd posture (\(P<0.01\)), and in 8th and 10th posture (\(P<0.05\)).

9.4.7 Changes in \(VCO_2\)

\(VCO_2\) was highest in the 11th posture and lowest in the 2nd posture in
case of Proficient. Semi-Proficient showed the highest value in 10th posture and lowest value in 1st posture. VCO₂ differed significantly between Proficient and Semi-Proficient in 3rd posture (P<0.001) and 8th posture (P<0.05).

9.4.8 Changes in VO₂/kg

Proficient showed highest VO₂/kg in 11th posture and lowest value in 2nd posture and Semi-Proficient showed highest value in 7th posture and lowest value in 1st posture. VO₂/kg differed significantly between Proficient and Semi-Proficient in 12th posture (P<0.05).

9.4.9 Changes in EQO₂

EQO₂ was highest in the 1st posture and lowest in the 7th posture in both the cases of Proficient and Semi-Proficient. EQO₂ did not show any significant difference between Proficient and Semi-Proficient in any of the twelve postures of SN.

9.4.10 Changes in EQCO₂

EQCO₂ was highest in 3rd posture and lowest in 7th posture in both the Proficient and Semi-Proficient. EQCO₂ did not show any significant difference between Proficient and Semi-Proficient in any of the twelve postures of SN.

9.4.11 Degree of achievement

The trainees achieved the level of proficiency to that of Proficient in different cardiorespiratory parameters like VO₂, HR, VO₂/kg, VCO₂, Vₑ and fᵣ during the practice of Surya Namaskar in the first phase of the training itself.

9.5 Discussion

VO₂, HR and O₂P did not show any significant difference in any of the postures between Proficient and Semi-Proficient. It indicates that Proficient in the present study are not better than Semi-Proficient. The Proficient may be irregular in their practice or detraining effects are prevalent on them. From the
Table 21 it appears that trainees achieved the level of proficiency to those of Proficient fully following three months of training. In case of O2P it was found out that in 75% cases (here postures) trainees showed proficiency to that of Proficient after 3 months of training. Cardiovascular conditioning is influenced by exercise training or due to ageing (30,95, 141). The yoga Proficient in this study are slightly aged (statistically not significant) than the yoga trainees. But it is least likely that the Proficient are having lower level of cardiovascular conditioning only due to the minor difference in age. The reason for this is that yoga trainees are infantry soldiers. They were participating in various outdoor games alongwith yogic training. In case of Proficient and Semi-Proficient they showed highest $V_E$, $f_R$ in the 11\textsuperscript{th} posture unlike trainees which showed highest value in the 8\textsuperscript{th} posture. Although from the sixth section it appeared that 8\textsuperscript{th} posture was the most strenuous amongst all other postures that contradicts the result obtained from the Proficient and Semi-Proficient. It may be due to detraining effects observed in the Proficient (133). Semi-Proficient showed comparatively lower value of $V_E$ and $f_R$ in some of the postures and comparatively higher value of $V_T$ in one posture than Proficient. This suggests that Semi-Proficient are having better respiratory conditioning than Proficient which may be due to the irregularity in the practice by the Proficient subjects.

As it is shown in the Table 14 respiratory parameters of trainees (after 3 months of training) like $V_E$ and $f_R$ achieved the values to that of Proficient. But $V_T$ did not show the similar trend. It may be due to delayed conditioning. So it shows the effects of Yogic training in Surya Namaskar becomes prominent first in cardiovascular system and the training effect on respiratory system is observed later (173).

Hence it may be inferred that so-called Proficient and Semi-Proficient did not show better training effect than trainees. It may be due to their irregularities in the practice or detraining effect.
Summary

The cardiorespiratory changes as recorded during the performance of SN by the Yoga Proficient and Semi-proficient subjects were compared with the trainees' value. It was observed here that $VO_2$ was highest in the 11th posture and lowest in 2nd posture in case of Proficient. In case of Semi-proficient it was found highest in 7th posture and lowest in 1st posture. $VO_2$ did not show any significant difference between Proficient and Semi-proficient in any of the twelve postures in the present study. HR was recorded highest in the 5th posture and lowest in 3rd posture in case of proficient and it was highest in the 7th posture and lowest in the 3rd posture in case of Semi-proficient. HR did not show any significant difference between Proficient and Semi-proficient. Proficient showed highest $V_E$ in 11th posture and lowest $V_E$ in 2nd posture. Semi-proficient showed highest $V_E$ in 11th posture and lowest in 3rd posture. $V_E$ differed significantly between Proficient and Semi-proficient in 3rd, 8th and 10th posture. $f_R$ was highest in 11th posture and lowest in 2nd posture in case of Proficient as well as in Semi-proficient. $f_R$ significantly differed between Proficient and Semi-proficient in 3rd, 4th and 12th posture. $V_T$ was highest in 7th posture and lowest in 3rd posture in case of Proficient and it was highest in 8th posture and lowest in 1st posture in case of Semi-proficient. $V_T$ differed significantly between Proficient and Semi-proficient in 9th posture ($P<0.05$). $VCO_2$ was highest in the 11th posture and lowest in the 2nd posture in case of Proficient. Semi-proficient showed the highest value in 10th posture and lowest value in 1st posture. $VCO_2$ differed significantly between Proficient and Semi-proficient in 3rd posture and 8th posture.

The trainees achieved the level of proficiency to that of Proficient in different cardiorespiratory parameters like $VO_2$, HR, $VO_2$/kg., $VCO_2$, $V_E$ and $f_R$ during the practice of SN in the first phase of the training itself. The $V_T$ did not show quick conditioning to that of other cardiorespiratory parameters. Regular Yogic training for three months may be sufficient to achieve the physiological status of Yoga Proficient subjects in this study. The Semi-proficient could not show the values like others that reflect detraining effect (due to irregular Yogic practice).
Figure 46. Oxygen consumption (litre/minute) in trainees at three different phases of training and in Proficients and Semi-proficients in 12 postures of Surya Namaskar. Values are mean±sem.
Figure 47. Heart rate (beats/minute) in trainees at three different phases of training and in Proficients and Semi-proficients in 12 postures of Surya Namaskar. Values are mean±SEM.

<table>
<thead>
<tr>
<th>Posture</th>
<th>1st phase</th>
<th>2nd phase</th>
<th>3rd phase</th>
<th>Proficients</th>
<th>Semi-proficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>65.0</td>
<td>91.5</td>
<td>99.8</td>
<td>109.5</td>
<td>109.0</td>
</tr>
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<td>108.0</td>
<td>98.3</td>
<td>90.4</td>
<td>109.0</td>
</tr>
<tr>
<td>3rd</td>
<td>85.0</td>
<td>107.0</td>
<td>100.0</td>
<td>105.0</td>
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</tr>
<tr>
<td>4th</td>
<td>86.4</td>
<td>106.4</td>
<td>108.4</td>
<td>105.0</td>
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</tr>
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<tr>
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<td>98.7</td>
<td>100.0</td>
<td>105.0</td>
</tr>
<tr>
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<td>91.0</td>
<td>100.0</td>
<td>105.0</td>
</tr>
<tr>
<td>9th</td>
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<td>89.7</td>
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<td>10th</td>
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</tr>
<tr>
<td>12th</td>
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<td>92.4</td>
<td>92.4</td>
<td>100.0</td>
<td>105.0</td>
</tr>
</tbody>
</table>

Comparison with 1st, 2nd and 3rd phase respectively:

• *P<0.05

•+*$P<0.01

•++*$P<0.001

Comparison between Proficients and Semi-proficients:

•$P<0.05

•+$P<0.01

•+++$P<0.001
Figure 48. Oxygen pulse (ml. per beat) in trainees at three different phases of training and in Proficients and Semi-proficients in 12 postures of Surya Namaskar. Values are mean±sem.

- 1st phase
- 2nd phase
- 3rd phase
- Proficients
- Semi-proficients

*/+/$ Comparison with 1st, 2nd and 3rd phase respectively
**/+/$@@ Comparison between Proficients and Semi-proficients
@ Comparison between Proficients and Semi-proficients
Figure 49. Breathing frequency (breaths/minute) in trainees at three different phases of training and in Proficients and Semi-proficients in 12 postures of Surya Namaskar. Values are mean±sem.

- 1st phase
- 2nd phase
- 3rd phase
- Proficients
- Semi-proficients

**+/++/$$@$ P<0.001
**/++/$$@$ @ P<0.01
*/+$/$@ P<0.05

* Comparison with 1st, 2nd and 3rd phase respectively
**+/++/$$@$ Comparison between Proficients and Semi-proficients

1st posture 2nd posture 3rd posture
4th posture 5th posture 6th posture
7th posture 8th posture 9th posture
10th posture 11th posture 12th posture
Figure 50. Tidal volume (litre/breath) in trainees at three different phases of training and in Proficients and Semi-proficients in 12 postures of Surya Namaskar. Values are mean±sem.

- **P<0.05**
- **P<0.01**
- **P<0.001**

@ Comparison between Proficients and Semi-proficients
Figure 51. Ventilation (litre/breath) in trainees at three different phases of training and in Proficients and Semi-proficients in 12 postures of Surya Namaskar. Values are mean±SEM.

- Comparison with 1st, 2nd and 3rd phase respectively
- Comparison between Proficients and Semi-proficients

*+/$ P<0.05
**/$@ P<0.01
***/@@@ P<0.001
Figure 52. Carbon dioxide output (litre/minute) in trainees at three different phases of training and in Proficients and Semi-proficients in 12 postures of Surya Namaskar. Values are mean±SEM.

1st posture 2nd posture 3rd posture

4th posture 5th posture 6th posture

7th posture 8th posture 9th posture

10th posture 11th posture 12th posture

Legend:
- 1st phase
- 2nd phase
- 3rd phase
- Proficients
- Semi-proficients

*+/★/★ Comparison with 1st, 2nd and 3rd phase respectively
**+/★★/★★/@★ Comparison between Proficients and Semi-proficients
***+/★★★/★★★/@@@ P<0.001
Figure 53. Relative values of oxygen consumption (ml./min./kg.) in trainees at three different phases of training and in Proficients and Semi-proficients in 12 postures of Surya Namaskar. Values are mean±sem.

Legend:

- • 1st phase
- • 2nd phase
- • 3rd phase
- • Proficients
- • Semi-proficients

- *//+/$/@@ P<0.05
- */++/$$/@@ P<0.01
- @ Comparison between Proficients and Semi-proficients
- /**+/+++/$$$/@@@ P<0.001

1st phase
2nd posture
3rd posture
4th posture
5th posture
6th posture
7th posture
8th posture
9th posture
10th posture
11th posture
12th posture

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Figure 54. Ventilatory equivalent for oxygen (EQO\textsubscript{2}) in trainees at three different phases of training and in Proficients and Semi-proficients in 12 postures of Surya Namaskar. Values are mean ± sem.

*++/S@ P<0.05
*/+/S@ P<0.01
***/+++/$$$@$@ P<0.001

1st posture 2nd posture 3rd posture
4th posture 5th posture 6th posture
7th posture 8th posture 9th posture
10th posture 11th posture 12th posture

1st phase 2nd phase 3rd phase Proficients Semi-proficients
Figure 55. Ventilatory equivalent for carbon dioxide (EQCO₂) in trainees at three different phases of training and in Proficients and Semi-proficients in 12 postures of Surya Namaskar. Values are mean±sem.

* Comparison with 1st, 2nd and 3rd phase respectively
@ Comparison between Proficients and Semi-proficients
@@ P<0.01
@@@ P<0.001
Table 19. A picture of status of different parameters with respect to that of Yoga Proficients and Semi-proficients in different phases of the Yoga training.

<table>
<thead>
<tr>
<th>$\text{VO}_2$</th>
<th>$\text{HR}$</th>
<th>$\text{O}_2\text{ PULSE}$</th>
<th>$\text{V}_E$</th>
<th>$f_r$</th>
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<td>A</td>
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<td>25</td>
<td>...</td>
<td>...</td>
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</tr>
<tr>
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<table>
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<tr>
<th>$\text{EO}_2$</th>
<th>$\text{VCO}_2$</th>
<th>$\text{VO}_2$/kg.</th>
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<td>II VS. PROF.</td>
<td>III VS. PROF.</td>
</tr>
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<tr>
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</tr>
<tr>
<td>A</td>
<td>25</td>
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</tr>
<tr>
<td>B</td>
<td>75</td>
<td>75</td>
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</table>

A % CASES NOT ACHIEVED THE LEVEL OF PROFICIENTS/ SEMI-PROFICIENTS
B % CASES ACHIEVED THE LEVEL OF PROFICIENTS/ SEMI-PROFICIENTS