Section VII

Comparative cardiorespiratory aspects of Surya Namaskar with respect to bicycle exercise at three different levels of work intensities
7. Comparative cardiorespiratory aspects of *Surya Namaskar* with respect to bicycle exercise at three different levels of work intensities

7.1 Introduction

*Surya Namaskar* (SN) is a group of yogic *Asanas* that take the form of twelve postures performed in a sequence of movements. During its performance, breath are made to flow simultaneously, easily and rhythmically (155). The practice of it includes all the basic components of Hatha Yogic practices i.e. *Asanas*, *Pranayama* and *Meditation* (192). This dynamic Yogic *Asana* was developed in the much later period in the evolution of Yogic *Asanas*. The beneficial effects of practicing SN are also being claimed by common men. People have adopted its practice as a form of aerobic exercise in their physical fitness programme. Literatures are very scanty regarding the comparison of SN with other forms of physical aerobic exercise like bicycle ergometric exercise, treadmill exercise, aerobic dance and several other forms. So the present study was carried out in an order to compare SN with the popular bicycle exercise. The comparison was based on the different cardiorespiratory responses.

7.2 Aim

The aim of the present study was to compare SN with bicycle ergometric exercise in terms of various cardiorespiratory responses at three different levels of work intensity such as at 10-20%, 21-40%, and 41-50% of the maximum oxygen uptake capacity.

7.3 Material and methods

20 young healthy men free from any clinical disorders were randomly chosen from a regiment of the Indian Army for the present study. The subjects had no prior experience of practicing yogic exercises. Their age, body weight and height are given in the Table 1. The subjects were briefed with details of the study protocol (both in English and Hindi language) before undertaking any kind of experiment on them.

They practiced SN daily in the morning with an empty stomach for 6 days in a week for 3 months under the supervision of a qualified yoga instructor. They practiced SN for one
round in 3min 40 sec. for the first 10 days from the day of commencement of the training. Then they gradually increased the number of rounds by two every 5 days until the attainment of 10 rounds for a particular session. Exactly after 90 days of the training (including the rest day) the subjects were asked to come to the laboratory and perform SN. Various cardiorespiratory parameters like $V_E$, $f_R$, $V_T$, $VO_2$, HR, $O_2P$, $VCO_2$, $EQO_2$, $EQCO_2$, were being monitored continuously with the help of the instruments as mentioned elaborately in the earlier section. Same Subjects performed on some other day the incremental load exercise test on an electrically braked bicycle ergometer upto the point of exhaustion for determining their maximal oxygen consumption ($VO_2^{\text{max}}$). All the cardiorespiratory parameters as recorded during SN were also recorded during bicycle exercise.

Three different ranges of work intensity as mentioned earlier were calculated out for the comparison of SN with the bicycle exercise.

Statistical analysis of the data was done by using two tail t-test for comparing different cardiorespiratory parameters of SN with that of the bicycle exercise at different range of work intensities for significant differences between the two.

7.4 Result

Different cardiorespiratory parameters recorded during SN as well as during maximal exercise were expressed into three different ranges of work intensity. The work intensity was calculated in terms of the percentage of maximal oxygen consumption. After the ranges of work intensity were fixed, the various cardiorespiratory responses in SN and bicycle exercise corresponding to that particular intensity were calculated. Figure 35 showed different parameters at three different levels of work intensities in SN and in bicycle exercise.

7.4.1 Heart rate

It was found that HR response at 10-20% of the $VO_2^{\text{max}}$ level was significantly higher ($P<0.05$) in SN as compared to bicycle exercise. At 21-40% of the $VO_2^{\text{max}}$ level, HR did not differ significantly between the two. At 41-50% of $VO_2^{\text{max}}$ level, HR was significantly higher ($P<0.001$) in bicycle exercise than SN.
7.4.2 Oxygen Pulse

At 10-20%, and 21-40% of the VO$_2$max level O$_2$P did not show any significant difference between SN and bicycle exercise. At 41-50% of VO$_2$max level O$_2$P was significantly higher (P<0.001) in SN than bicycle exercise.

7.4.3 Ventilation

At 10-20% and 41-50% of the VO$_2$max level, VE was significantly higher in bicycle exercise than SN at P<0.01 and P<0.001 level respectively. 21-40% level did not show any significant difference.

7.4.4 Breathing Frequency

At 21-40% of the VO$_2$max level fr was significantly higher (P<0.05) in bicycle exercise than SN. Rest of the two levels did not show any difference between the two.

7.4.5 Tidal Volume

At 21-40% of the VO$_2$max level VT was significantly higher (P<0.05) in SN than in bicycle exercise. Rest of the two levels did not show any difference between the two.

7.4.6 Ventilatory Equivalent for Oxygen

At 10-20%, 21-40% and 41-50% of the VO$_2$max level, EQO$_2$ was significantly higher in bicycle exercise than SN at P<0.001, P<0.001 and P<0.01 level respectively.

7.4.7 Ventilatory Equivalent for Carbon dioxide

EQCO$_2$ was significantly higher (P<0.001) in bicycle exercise than SN at both the 10-20% and 21-40% of the VO$_2$max level. 41-50% of the VO$_2$max level did not show any significant difference between the two.

7.4.8 Carbon dioxide Output

At 41-50% of the VO$_2$max level VCO$_2$ was significantly higher (P<0.01) in bicycle exercise than SN. Rest of the two levels did not show any significant difference between the two.
7.5 Discussion

At lower range of the work intensity (10-20% of the VO₂ max.) HR was found to be significantly (P<0.05) higher in SN than in bicycle exercise. At 21-40% of the VO₂ max level HR was non-significantly higher in SN than in bicycle exercise. Yogic Asanas are characterized by presence of slow, static and isometric component (173). SN practice involves both the static and dynamic components of the exercise. Various investigators have shown that isometric muscular contraction cause an increase in heart rate (49, 51, 54, 197) and this increase is dependent upon the intensity of the contraction (99, 204-206, 237). Iwamoto and Botterman had shown in cats that the degree of increment in HR varies directly with the size of the active muscle mass involved (76). Experiments on human subjects have also shown that cardiovascular response to static contraction is directly proportional to the size of the active muscle mass involved (102, 122, 176, 203). At lower intensity of exercise (in terms of % VO₂ max.) the higher HR in SN may be explained on the basis of isometric contraction induced HR. The Isometric component of SN may be giving an additional input for higher HR in SN in addition to the various other factors. In SN practice, it could be hypothesized that the higher heart rate value is related to an additional static exercise component. In one such study, it has been shown that the imposition of a static exercise component on dynamic exercise increases submaximal heart rate response (153 a). At higher intensity (41-50% VO₂ max) the result was just reverse. Here, in bicycle exercise (21) various other factors take the predominant role for higher HR in it than SN. Because during the practice of SN some of the factors like accumulation of local metabolite, increase in body temperature may be considered as negligible as compared to conventional physical exercise. These factors also play a dominant role in the rise of heart rate during exercise O₂P which indicates the oxygen transport (47, 183) was found to remain almost similar at 10-20% and 21-40% of the VO₂ max.

At 41-50% VO₂ max work intensity, comparatively higher O₂P in SN indicate better oxygen transport in it than bicycle exercise. Higher O₂P in SN is attributed to the comparatively lower HR in it at this particular work intensity because O₂P is the ratio of O₂ consumption to HR. The increase in Vₐ during exercise is partly due to the proprioceptive afferent impulses from the muscles and joints and partly due to stimulatory collateral impulses from the higher centres of the brain (motor cortex) to the respiratory centre (70).

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During exercise muscle contraction takes place because of the same stimulatory motor impulses from the higher centres of the brain. Thus, the brain tells the muscle what and how much work to do and informs the supporting cardiovascular and respiratory systems of their task (70). In the present study the work intensity in SN as well as in bicycle exercise may be considered as moderate level of exercise. Relatively higher value of $V_E$ in bicycle exercise at lower and higher work intensity may be due to more proprioceptive impulses from the muscles, joints, and tendons concerned or may be due to strong motor impulses from the higher centres of the brain commensurate with the nature and frequency of the muscle contraction of bicycle exercise. $V_E$ during exercise can be increased by two ways either by increasing the rate of respiration or by increasing $V_T$ or both. In the present study although $V_E$ was significantly higher in bicycle exercise at work intensity cf 10-20% and 41-50% of the $V_{O_2}\text{max}$. Strikingly $f_R$ and $V_T$ did not differ significantly between SN and bicycle exercise at these two work intensities. The product of $f_R$ and $V_T$ at these two work intensities make the ventilation to be significantly different. 21-40% of the $V_{O_2}\text{max}$ although there was higher $f_R$ and lower $V_T$ in bicycle exercise. The product of $f_R$ and $V_T$ did not make $V_E$ to be different from one another. $VCO_2$ output depends upon the metabolic activity of the cell that is further dependent upon the intensity of the exercise. In the present study the amount of carbon dioxide produced in bicycle exercise exceeded than that produced in SN at higher level of work intensity (41-50% of the $V_{O_2}\text{max}$). Though SN is dynamic in nature amongst other yogic asanas, it is executed slowly unlike bicycle exercise that is performed at a fixed cadence (here at about 40-60 revolutions per minute). At similar level of energy demand (41-50% of $V_{O_2}\text{max}$) the greater carbon dioxide output in bicycle exercise may be due to higher ventilatory drive (significantly higher $V_E$ in bicycle exercise at 41-50% of $V_{O_2}\text{max}$) probably resulting from higher PCO$_2$ in the blood produced during bicycle exercise.

During the practice of SN load is distributed amongst various groups of muscles in the body unlike bicycle exercise where load is exerted constantly and exclusively on most of the lower part of the body. Hence it may be opined that metabolic stress is more in bicycle exercise than SN at similar level of energy demand (41-50% of $V_{O_2}\text{max}$).
Ventilatory equivalent for oxygen (EQO₂) obtained during 10-20%, 21-40% and 41-50% of the VO₂ max work intensity was always significantly higher in bicycle exercise. This indicates that SN practitioners had more efficient breathing patterns during its practice at similar level of work intensity. In a similar study Schneider and Leung had compared the EQO₂ between two Chinese conventional exercise namely T’ai Chi Chuan and Wing Chun. They showed that at a work intensity in the range of 36-52% of the VO₂ max. EQO₂ was higher in Wing Chun Exercise (24.2) than T’ai Chi Chuan exercise (21.7). This suggests that T’ai Chi Chuan exercise may have an edge over Wing chun exercise from the ventilatory point of view (199).

Ventilatory equivalent for carbon dioxide also showed significantly higher value in bicycle exercise at 10-20% and 21-40% of the VO₂ max. work intensity suggesting that SN practitioners may have a lower metabolic load than bicyclist (199).

From the foregoing discussion it may be concluded that cardiorespiratory stress is more in bicycle exercise than SN.
Summary

The SN as performed by Yoga trainees after three months of yogic training was compared with bicycle ergometric exercise in terms of various cardiorespiratory responses at three different levels of work intensities such as at 10-20% (low intensity), 21-40% (moderate intensity) and 41-50% (higher intensity) of the VO₂max level. It was found out that HR response at low and moderate work intensity was higher in SN than in bicycle exercise. The higher heart rate in SN at low and moderate work intensity is perhaps due to imposition of a static exercise component on dynamic exercise (153a). At higher work intensity, HR was significantly higher in bicycle exercise than in SN. At low and moderate work intensity O₂P did not show any significant difference between SN and bicycle exercise. At higher work intensity O₂P was significantly higher (P<0.001) in SN than in bicycle exercise. At low and higher work intensity, Vₑ was significantly higher in bicycle exercise than in SN at P<0.01 and P<0.001 level respectively. At moderate work intensity fₚ was significantly higher (P<0.05) in bicycle exercise than in SN. At moderate work intensity Vₜ was significantly higher (P<0.05) in SN than in bicycle exercise. At higher work intensity VCO₂ was significantly higher (P<0.01) in bicycle exercise than in SN.

Comparing the various cardiorespiratory data of SN and bicycle exercise it appeared that cardiorespiratory stress is more in bicycle exercise than in SN at similar work intensity.
Figure 35. Different cardiorespiratory parameters during Surya Namaskar and bicycle exercise at 10-20%, 21-40% and 41-50% of maximal aerobic capacity. Values are mean ±sd.