Surya Namaskar: As an Alternative for Aerobic Fitness

Abstract

Context: “Surya Namaskar” (SN) may be used as a need-based short-duration aerobic activity in a confined space to establish an equivalent routine physical training in challenging stressful conditions. Materials and Methods: Noninvasive oxygen-kinetics metabolic responses between SN and endurance work on bicycle ergometry (BE) were compared across different phases of maximal oxygen uptake percentage (%VO_{2\text{max}}). SN, comprising three complete rounds per min (36 beats/min of a metronome; SN consists of 12 poses per round), was performed rhythmically and continuously for 5 min to simulate an incremental BE test (25 watts/2 min at 60 rpm). Results: SN results in a significant (P < 0.05) greater increase of arteriovenous oxygen difference at 71%–80% VO_{2\text{max}} while keeping a low respiratory exchange ratio (P < 0.01 and 0.001) at 41%–80% VO_{2\text{max}} exercising state. Conclusions: SN could be an ideal form of aerobic exercise instead of BE.

Keywords: Dynamic yoga, incremental exercise test, maximal oxygen uptake percentage

Introduction

To ascertain strength–power capabilities, and fatigue resiliency under moderate intensity (MI) there is a prerequisite of a short-duration, aerobic activity in a confined space substituting traditional exercise regimes for the challenging stressful situation. Combat fitness is one of prerequisite to maintain regular physical fitness even in extreme adverse environmental conditions where exercise in open air is difficult such as Antarctica, cold and high altitude, hot desert, and microclimate in submarine and space. In these challenging conditions, Surya Namaskar (SN) could be a useful fitness substitute to maintain regular exercise regime.

SN or Sun Salutation, a component of Hatha yoga, consisting of a series of 12 postures (asanas), performed rhythmically with controlled breathing in one round without any pause in between and also involves both static and dynamic musculoskeletal stretching exercises recruiting the majority components of the spine, joints, and muscles of the body.[1,2] The most common variation, i.e., Sun Salutation, can be practiced to achieve an aerobically intense effort (metabolic equivalents [METS] up to 7.4 with 80% maximal heart rate [HRmax], at the pace of 3 min per round)[3] by incorporating rapid transition jumps and full pushups in between asanas.[4]

In bicycle ergometry (BE), the exercise capacity at a specific level of workload is exerted immediately and solely on lower limb muscles unlike progressive increment disseminating among various groups of muscles in SN from 1st to successive rounds. Previously, at a similar level of exercise intensity (i.e., 41%–50% of VO_{2\text{max}}), the metabolic stress was reported to be greater in BE than SN.[5]

Although the reported research[6] was aimed at ≤50% VO_{2\text{max}} in terms of progressive work intensities; research beyond this level and focusing majorly the stroke volume (SV), cardiac output (Q), a-vO_2 diff. response is still unavailable. Considering the same central and peripheral cardiovascular factors, the current study was aimed to compare SN and BE across low to exhaustive phases of exercise intensities.

Materials and Methods

Study design

This study was self-control.

Subjects

The study was approved by the Institutional Ethical Committee (viz., Ref. No. IEC/163)

Address for correspondence:
Dr. Mantu Saha,
DIPAS, DRDO, New Delhi, India.
E-mail: msaha@dipas.drdo.in

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DIPAS/A-4/2) considering the Helsinki Declaration of 1975, as revised in 2000. Seven (n = 7) physically fit men involved in routine physical training, and without any history of medication (mean age: 32.6 ± 1.97, years; height: 172.0 ± 7.09, cm; body weight: 76.8 ± 5.86, kg) were recruited. The subjects for this study were the defense personnel posted in DRDO.

**Procedures**

The volunteers have practiced SN adequately for over 2 years and performed SN comprising three complete rounds per min continuously for a total duration of 5 min by wearing a portable metabolic cart (START 200M Ergospirometer, MES, Poland) in a thermoneutral room. Each pose of SN [Figure 1] was standardized with each beat of a metronome set in 36 beats/min.

After 1 day of rest, a standard graded BE test (using Monark LC4 G3, Sweden) at an incremental workload of 25 watts/2 min at 60 rpm was conducted on the same volunteers till exhaustion.

Informed consent was obtained and noninvasive measurements of heart rate (HR) (by Polar H10, Finland) and VO\(_2\)\(_{\max}\) followed by minute ventilation (VE), Q, SV, arteriovenous oxygen difference, and respiratory exchange ratio (RER) were recorded. SN and BE were compared at similar maximal oxygen uptake percentage (%VO\(_2\)\(_{\max}\)) level.

**Data analysis**

Average VO\(_2\)\(_{\max}\) of SN practice (at the end of 5 min) and BE was recorded 34.0 ± 11.99 and 43.6 ± 13.63 ml/kg/min, respectively. Eight exercise intensities equivalent to an energy expenditure of 10%–80% VO\(_2\)\(_{\max}\) for light intensity (10%–20% and 21%–30%), MI (31%–40% and 41%–50%), high intensity (HI) (51%–60% and 61%–70%), and very HI (VHI) (71%–74% and 75%–80%) were evaluated both from SN and BE VO\(_2\)\(_{\max}\) (average). The parameters at different phases were compared keeping %VO\(_2\)\(_{\max}\) as constant. Two-factorial ANOVA while considering “exercise intensity” and “type of exercise” both as factors followed by Bonferroni’s post hoc test was applied using SPSS (SPSS Statistics for Windows, version 27.0 IBM Corp., Armonk, N.Y., USA).

**Results**

From the MI (31% VO\(_2\)\(_{\max}\)) onward, BE showed a tendency to overestimate HR, VE, Q, SV, and RER as evident by Table 1. SN results a significant (P < 0.05) greater increase in C (a-v) \(\text{O}_2\) at the VHI (71%–80% VO\(_2\)\(_{\max}\)) [Figure 2a] keeping lower RER values (P < 0.01, 0.001) between moderate and VHI (41%–80% VO\(_2\)\(_{\max}\)) [Figure 2b].

**Discussion**

At the initial phase, the higher values of the parameters in SN might be due to “muscle metaboreflex” caused by the forceful isometric contraction-induced accumulation of local metabolites, attributing also similar SN and BE values at 31%–40% VO\(_2\)\(_{\max}\) as a carryover effect.

When exercise intensity has progressed into the higher side (41%–50% VO\(_2\)\(_{\max}\) onward); HR, VE, Q, and SV in BE was increased predominantly by muscle chemoreflex and “central command,” decreasing parasympathetic activity to the sinus node while activating central neuronal circuits,

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**Figure 1: Flow transitions of asanas in SN. SN: Surya Namaskar**
Table 1: Comparison of heart rate, minute ventilation, cardiac output and stroke volume during Surya Namaskar and bicycle ergometry at different exercise intensities

| Exercise intensity | SN | BE |
|--------------------|----|----|
| %VO$_2$ max (%)    |    |    |
| 5-20 (LIH)         | 101±15.09 | 105.7±18.02 |
| 21-30 (LI-III)     | 106±17.92 | 110±18.02 |
| 31-40 (MI-II)      | 115±19.02 | 119±20.02 |
| 41-50 (MI-IV)      | 120±21.02 | 123±22.02 |
| 51-60 (HI-V)       | 125±23.02 | 128±24.02 |
| 61-70 (HI-VI)      | 129±25.02 | 132±26.02 |
| 71-80 (HI-VII)     | 132±27.02 | 135±28.02 |
| 81-90 (HI-VIII)    | 135±29.02 | 138±30.02 |
| 91-100 (HI-IX)     | 138±31.02 | 141±32.02 |

Significantly different from (I) group, $*P<0.05$, $**P<0.01$, $***P<0.001$.

The amount of CO$_2$ produced in BE was significantly exceeded that produced in SN due to strong ventilatory drive resulting from higher blood PCO$_2$ produced at 41%–50% VO$_2$ max causing a higher RER [Figure 2b]. Potentially, the increase in VE without an increase in O$_2$ extraction (since Ca-vO$_2$ difference increases at the high intensities) might be an important reason to surge Q to meet the subjects’ aerobic response in BE. C (a-v) O$_2$ (i.e., the difference in the O$_2$ content between arterial and venous blood) represents the body’s ability to oxygenate the blood. The greater the amount of O$_2$ extracted by the tissues, the greater the a-vO$_2$ difference; therefore, higher a-vO$_2$ difference resulted with exercise intensity as blood flow to the tissues increases, and hemoglobin dissociates more easily.

Adding arm exercise to ongoing leg exercise activities alters hemodynamic and neural responses than exercises involving only leg muscles at similar O$_2$ cost. Therefore, collective perfusion of all of the active muscles might improve the overall limitation of Q on muscle blood flow and O$_2$ delivery. The challenges to venous return and cerebral blood flow are associated with different postures, as blood pressure changes during head-down poses of SN; it also, plays a key role in the cardiovascular response. Possibly, the complex interactions between the sympathetic nervous system and the microcirculation during upright posture versus the horizontal position (i.e., baroreflex resetting thereby altering perfusion of central nervous system and vital organs) facilitate high levels of systemic O$_2$ extraction and permit just enough sympathetic control of blood flow (i.e., sympathetic vasoconstriction) to the contracting muscles to regulate blood pressure.

In reports, SN practitioners hold a particular posture for 15–20 s followed by transitioning onto the next posture by the dynamic action of the muscles, thus causing cessation of the isometric contraction phase. Moreover, muscle metaboreflex during SN at this phase, unable to cause further increment by controlling either parasympathetic or sympathetic efferent activity. During a specific muscle mass exercise, the venous O$_2$ saturation value is higher than during whole-body exercise because skeletal muscle mitochondria can operate at a very low partial pressure of oxygen. This low-deep venous O$_2$ saturation allows O$_2$ extraction to increase further and consequently, as a resultant effect of an induced O$_2$ diffusion capacity by the involvement of slow type (i.e., Type I) muscle fibers during SN [Figure 2a]. Reducing blood flow to contracting muscle to regulate arterial pressure is also a causative factor of very low deep venous saturation.
proprioceptive and neuromotor exercise) with purposive frequency, intensity, time, and volume. SN could be performed in multiple sessions of ≥10 min or could be slowed down by holding a static stretch for 10–30 s also recommended for most adults.

Practicing SN at 51%–60% VO$_2$ max (i.e., at 7 METS) for ≥25–50 min/day on ≥3–5 day/week reaches the weekly goal of ACSM’s criteria (i.e., 150 min/week of total exercise volume and energy expenditure of ≥500–1000 MET. min/week or ≈1400 kcal/week) for cardiorespiratory fitness in adults.

However, more appropriately, as per relative measure of intensity, middle-aged (40–64 years) person working at six METs (i.e., at 41%–50% VO$_2$ max of SN) may be exercising at a vigorous to maximal intensity as per HRmax, whereas a younger person working at the same absolute intensity will be exercising moderately.\(^{[14]}\)

On the other hand, practicing SN for ≥20–40 min/day on ≥3–5 day/week at 61%–70% VO$_2$ max (i.e., at 8 METS), meets directly the criteria for young adults (20–39 years) as vigorous-intensity cardiorespiratory exercise training reaching the recommended volume of ≥75 min/week.

In accordance with Mody,\(^{[3]}\) time to exhaustion in SN in current study is significantly lower than BE at higher intensities, yet we studied purposely only for 5 min at 3 rounds/min paces. Again, well-trained athletes require “near-maximal” (i.e., 95%–100% VO$_2$ max) training intensities to improve VO$_2$ max. On the other hand, in moderately trained athletes, 70%–80% VO$_2$ max seemed to provide a sufficient stimulus of enhancement.\(^{[15]}\)

Therefore, SN at similar intensity range could be ideal to be incorporated into high-intensity interval training (HIIT) regimen for enhancing VO$_2$ max.\(^{[14]}\)

**Limitations of the study**

Special recruitment restricted low sample size and simple methodology was the key limiting factor.

**Clinical implications**

This study enables a new approach of easily implementable, whole-body moderate-intensity workout at any confined situation in minimum requiring space without any equipment during any challenging conditions.

**Conclusions**

The practice of SN demands less metabolic stress with a widespread workload distributed among various muscle groups thereby restraining blood flow and other metabolites accumulation in a single active muscle eventually causing higher peripheral O$_2$ extraction capacity. Therefore, SN could be another form of aerobic exercise with equivalent BE-VO$_2$ kinetics, and a lower RER of SN could be utilized for short-duration aerobic training.

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**Conflicts of interest**

There are no conflicts of interest.

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