

JEPonline
Journal of Exercise Physiologyonline

**Official Journal of The American
Society of Exercise Physiologists (ASEP)**

ISSN 1097-9751

An International Electronic Journal
Volume 4 Number 3 August 2001

Metabolic Responses to Exercise

**ENERGY COST AND PHYSIOLOGICAL EFFICIENCY IN MALE YOGA
PRACTITIONERS**

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ABSTRACT

K.V.V. PRASAD, Y. VENKATA RAMANA, P.S. RAJU, M. VENKATA REDDY AND K.J.R. MURTHY. **Energy Cost And Physiological Efficiency In Male Yoga Practitioners**. JEPonline. 2001;4(3):38-44. Pranayama is a basic yogic breathing technique, of which one of the methods is nadisodhana wherein breathing is performed through alternate nostrils. The present study aims at identifying the energy cost of nadisodhana and compare it with standard physical activities such as controlled treadmill-walking and field-walking. The present study was conducted on twelve normal healthy male volunteers who have been practicing yoga and pranayama over a period of three years. The energy cost of nadisodhana and field-walking was derived from individual regression equations using oxygen consumption and heart rates recorded during a maximal graded exercise test on treadmill carried out in a thermoneutral environment. The predicted oxygen consumption and heart rate during nadisodhana were significantly lower than in field-walking ($p < 0.05$ & 0.01) and treadmill-walking ($p < 0.01$ & 0.01) indicating that the energy cost for nadisodhana is lower. Oxygen pulse during nadisodhana was also significantly lower than field-walking ($p < 0.05$) and treadmill-walking ($p < 0.05$). It was also observed that during nadisodhana blood lactate was significantly lower ($p < 0.01$ & 0.05) than during the other two tests studied and pyruvate was significantly higher ($p < 0.01$) than during treadmill-walking. The results indicate low exertion on the subjects, based on Borg scale during nadisodhana than in other forms of physical exercises. This low exertion may be attributed to efficient metabolic adaptations during nadisodhana. In view of the above findings nadisodhana can be included in the battery of fitness programs for both healthy and diseased individuals.

Key Words: Nadisodhana, treadmill-walking, field-walking, oxygen consumption, heart rate

INTRODUCTION

Yoga is an ancient Indian science and its practice is known to improve and maintain health status by improving cardio-vascular, cardio-respiratory and other functional capabilities and also prevent various ailments. Nadisodhana is part of pranayama practice wherein breathing is carried out through alternate nostrils. Studies on nadisodhana have shown an improvement in various cardio-respiratory functions among normal volunteers (2-5) and also in controlling diseases like diabetes (6-10).

A few studies have reported the oxygen consumption during different types of pranayama by direct measurement (11-13). These studies have reported increased oxygen consumption by 12-14% over basal values.

It is an established fact that oxygen consumption can be predicted using the relation between heart rate and oxygen consumption recorded while performing controlled standardized exercise (14-16). Based on this linear relationship between heart rate and oxygen consumption, considering the beneficial effects of yoga and pranayama in both health and disease conditions, the present study was carried out to assess the oxygen requirement during nadisodhana. This is derived by indirect method and to compare this with controlled physical activities like field-walking and treadmill-walking.

METHODS

Twelve normal healthy male volunteers aged between 18 to 30 years, who were practicing yoga regularly over three years, were selected from among the yoga practitioners in Vemana Yoga Research Institute, Hyderabad, India. They were briefed about the purpose and benefits of the study protocol and their written consent was obtained based on the guidelines of the institutional ethical committee.

Each individual was subjected to four types of tests; 1) Nadisodhana for 30 min. 2) Treadmill-walking for 30 min. 3) Field-walking for 30 min. and 4) a graded maximal exercise test. A test trial of these four activities was given to each individual a week prior to the actual test to acquaint them with the procedure so as to avoid anxiety, which would otherwise interfere with the results. All these tests were conducted in a supine awakened post-absorptive state in the morning between 7am and 8am after one hour of bed-rest. Each of these tests was carried out on four consecutive days covering one test a day in the laboratory, except for field-walking. The graded maximal exercise test was performed on the fourth day to avoid any carry over effects of exercise-induced thermogenesis.

Blood was collected from all subjects before and immediately after each of the first three tests for the analysis of lactate and pyruvate. Blood lactate and pyruvate were quantified by enzymatic spectrophotometry (Boehringer and Mannheim, Germany). A lactate and pyruvate ratio was then calculated from these values.

All the subjects were asked to record their view regarding their effort during all the testing. A proforma was developed based on the perceived exertion rating (PER) as recommended by Borg (1) and was circulated to each subject. The information obtained from the subjects was analyzed and the perceived exertion rating of each activity was evaluated using a revised brief scale (1-10) and compared the values of nadisodhana with both field-walking and treadmill-walking to aid in the estimation of exercise intensity.

A well-trained investigator recorded the anthropometric measurements of the subjects. Body height was measured to the nearest to 0.1 cm, and body weight, with minimum clothing, to the nearest to 0.1 kg (Seca, Germany). The fat fold thickness at four sites was measured nearest to 0.2mm using skin fold calipers (Holtain, UK). The fat free mass (FFM) and fat mass were calculated using age and sex matched equations (17).

Nadisodhana

Nadisodhana (18) is one of the basic techniques of pranayama, a basic yoga breathing procedure. It is a slow, continuous and deep breathing process through alternate nostrils practiced at 1:2 ratio (inhalation and exhalation) carried out in Vajrasana (a yoga sitting posture) or in any meditative posture. The inhalation and exhalation were carried out for 8 seconds and 16 seconds respectively which comprises one cycle. After five such cycles the subjects were asked to breathe normally for one minute. All the subjects performed nadisodhana continuously for 30 min. The heart rate during nadisodhana was recorded using electrocardiography (Olli, Finland).

Treadmill-Walking

Treadmill walking was carried out for 30 min at 3 km/h in the laboratory. The subjects' heart rates were recorded using electrocardiography. Minute ventilation (V_E), fractional expired oxygen (FEO_2) and fractional expired carbon dioxide ($FECO_2$) were recorded using a fully automated calorimetry system (PK Morgan Ltd., model 901-MK2, UK).

Field-Walking

The field-walking was conducted on a standard 400 m track demarcated for 1.5 km. Each subject was told to walk for 3.75 laps covering a distance of 1.5km in 30 min., which equaled the distance covered during controlled treadmill-walking. The heart rate was recorded using a heart rate monitor (PE-3000, Polar Instruments, Finland).

Maximal Graded Exercise Test

The maximal graded exercise test was performed on treadmill (Venky Ltd., India) using the Bruce protocol (19). V_E , FEO_2 and $FECO_2$ were recorded at rest and during each stage of the protocol until volitional exhaustion or reached their predicted maximal heart rate, whichever was first (20). Oxygen pulse was calculated from oxygen uptake and heart rate during each stage, and for each activity. The V_E , FEO_2 and $FECO_2$ were measured breath- by- breath (PK Morgan Ltd., model 901-MK2, UK) and heart rates were recorded simultaneously using electrocardiography (Olli, Finland). A regression line was derived using heart rate and oxygen consumption (VO_2) recorded at each stage of Bruce protocol, including the peak VO_2 . Regression lines were drawn for each subject independently, to avoid any individual variations in indirect determination of oxygen consumption during field walking and Nadisodhana. These regression equations were then used to calculate the oxygen consumption and energy cost of nadisodhana and field-walking.

The energy cost of each activity was derived using oxygen consumption corrected to non-protein respiratory quotient (21). The BMR factor (METS) was derived using the energy cost of the particular activity divided by the energy cost at basal condition. oxygen consumption per unit body weight and per unit FFM was calculated.

Statistical Analysis

The Student's 't' Test was used to analyze mean differences between nadisodhana and field-walking, and treadmill-walking and standing on the treadmill. The values were expressed as Mean \pm SD. Significance was accepted at $p < 0.05$.

RESULTS

The anthropometric measurements and body composition were given in Table 1. The values are comparable with the Indian population in height, weight and body composition.

Table 1: Physical Characteristics (n=12)

Parameters	Age (Yr)	Height (m)	Body Weight (kg)	BMI (kg/m ²)	FFM (kg)	Fat (%)
Mean \pm SD	27.1 \pm 10.7	1.69 \pm 0.07	59.96 \pm 8.5	21.27 \pm 2.28	48.87 \pm 5.32	18.13 \pm 5.16

The physiological observations are presented in Table 2. Heart rate and oxygen consumption of nadisodhana, and field and treadmill-walking were compared with that of basal metabolic rate (BMR) to record the

percentage of change over basal values. There had been 1.4 fold, 3 fold and 2.4 fold increases in oxygen consumption over the basal values for these trials, respectively. Heart rate and oxygen consumption of field and treadmill-walking were compared with that of nadisodhana. The heart rates and oxygen consumption during nadisodhana were significantly lower than during field-walking and treadmill-walking. On the other hand it was observed that the heart rates during nadisodhana and standing were comparable; the oxygen consumption of nadisodhana was significantly lower than standing values. It had also been observed that the oxygen pulse during nadisodhana was significantly lower than treadmill-walking and field-walking.

The oxygen consumption as was derived from regression equation for nadisodhana was found to be significantly lower than for field-walking and treadmill-walking. On the other hand, based on the PER it can be confirmed that the intensity during nadisodhana was found to be significantly lower than both field-walking and treadmill-walking.

Table 2: Physiological Responses During Different Tests (n=12)

<i>Parameters</i>	<i>BMR</i>	<i>Standing</i>	<i>MGXT</i>	<i>TMW</i>	<i>FW</i>	<i>Nadisodhana</i>
<i>VO₂ (L/min)</i>	0.18±0.03	0.57±0.24*	2.51±0.54	0.72±0.11**	0.56±0.19*	0.45±0.10
<i>VO₂ (ml/kg/min)</i>	3.09±0.75	9.57±4.21**	41.91±8.03	12.00±1.32**	9.36±2.66**	6.66±1.33
<i>VO₂ (ml/kg FFM/min)</i>	3.75±0.78	11.62±4.77**	51.41±10.37	14.69±1.64	11.41±3.19**	7.51±1.57
<i>Energy Cost (Kcal/min)</i>	0.91±0.17	2.84±1.22*	12.55±2.71	3.59±0.55**	2.80±0.93*	2.23±0.51
<i>Heart Rate (beats/min)</i>	56.0±4.3	65.6±6.31	157.8±11.2	80.2±5.8**	74.8±6.5**	66.9±3.7
<i>O₂ PULSE (ml/beat)</i>	3.24±0.53	8.63±3.36*	16.00±3.80	8.98±1.49*	7.39±1.93*	6.66±1.33
<i>METS</i>	1.00	3.16±1.16*	14.28±4.21	4.09±1.05**	3.11±0.89*	2.52±0.66
<i>PER</i>	-	-	9.25±0.75	4.25±0.97***	3.42±0.51***	2.08±0.67

All values expressed as Mean±SD; Significance noted at *p<0.05, **p<0.01, ***p<0.001

It was observed that the lactate levels were significantly lower during nadisodhana than during the other tests, while the pyruvate levels were significantly higher (Table-III). The lactate/pyruvate ratios were also lower than during the other tests and basal levels.

Table 3: Biochemical Responses During Different Tests (n=12)

<i>PARAMETERS</i>	<i>BMR</i>	<i>TMW</i>	<i>FW</i>	<i>NADISODHA NA</i>
<i>LACTATE (̂M)</i>	475.5±34.5	774.3±107.7**	704.2±82.5*	608.8±38.20
<i>PYRUVATE (̂M)</i>	46.3±12.70	52.0±8.0**	73.6±18.9**	94.1±18.60
<i>L / P ratio</i>	10.76±2.29	15.08±2.37**	10.49±4.77*	6.64±1.09

All values expressed as Mean±SD; Significance noted at *p<0.05, **p<0.01

DISCUSSION

Nadisodhana is an integral part of yoga, which is an ancient Indian practice. It has been reported that practicing nadisodhana has beneficial effects on the cardiorespiratory system among normal volunteers and athletes (2-5). Several studies have also indicated the beneficial effects of pranayama on various disorders such as diabetes (6,7), asthma (8,9) and hypertension (10).

Changes in oxygen consumption during different types of yoga breathing practices (pranayama) has previously been reported. One study (11) had reported an increase of 12.35% in oxygen consumption above basal level, during yoga type breathing practices. Another study (12) had showed decreased oxygen consumption during Ujjayi pranayama practice in the subjects who were practicing yoga for more than 6 months. Yet another study (13) had reported an increased oxygen consumption during Bhastrika pranayama.

Earlier, studies have been carried out to identify the effect of yoga and pranayama on athletic performance while doing sub-maximal and maximal exercise by three different types of combinations of yoga practice; short-term yoga practice (3), long-term yoga practice (2) and short-term intensive yoga practice (4). The studies during short-term (3 months) yoga practice have showed a significant reduction in minute ventilation and oxygen uptake during sub-maximal exercise test in normal volunteers (3). It was also observed that the subjects were able to do this sub-maximal exercise test after yoga training without a significant elevation in blood lactate.

It has also been reported that the practice of yoga improved exercise efficiency (decreased VO_2) during sub-maximal exercise test (2). For example, it was reported that after yoga training work output had increased by 307% and oxygen uptake increased by only 17%, indicating an improvement in the utilization of oxygen.

The results in the present study during graded exercise show that the maximal work output is lower than that predicted for their corresponding heart rates. It would seem rather obvious that the physiological demands of walking at this velocity are more demanding than the comparatively passive demands imposed by nadisodhana. This observation is also supported based on PER as expressed by the subjects immediately after completion of tests.

In the present study the oxygen consumption during nadisodhana practice was significantly higher than that recorded during basal metabolic rate, and is significantly lower than the values obtained during field-walking and treadmill-walking. It was also noted that the oxygen consumption during nadisodhana was lower than that of the standing position.

It was noted during nadisodhana that the subjects' inhalation and exhalation were deep with reduced respiratory frequency. Slow deep breathing appeared to be altering the normal respiratory stimulation of these subjects, which could be the reason for lower oxygen consumption. During nadisodhana, though the subjects were sitting in a quite comfortable yogic posture, the heart rates were found to be 14% higher than the basal condition. When BMR Factor (METS) (i.e., the ratio between energy cost of a given activity to that of basal level) was looked into account it was observed that the values were 2.52, 3.11 and 4.09 for nadisodhana, field-walking and treadmill-walking respectively. This clearly indicates that the energy cost of nadisodhana is much lower than that of the other two activities. However, when considering the biochemical aspects, the lactate was relatively lower and pyruvate level was higher in nadisodhana than field and treadmill-walking indicating low fatigability and efficient conditioning of aerobic metabolic mechanisms.

CONCLUSIONS

Based on these observations it can be suggested that the practice of nadisodhana on a regular basis would be beneficial to individuals in general and specifically to those who cannot take up exercise like treadmill-walking and field-walking as a part of fitness program. Thus, it can also be included in the battery of fitness programs for both healthy and diseased individuals, as nadisodhana is a low intense activity (based on PER) with meaningful physiological benefits. Secondly, considering its influence on aerobic metabolism and delaying in fatigability, the authors recommend that the practice of pranayama can be included in the battery of training schedule of athletes to achieve better performance.

ACKNOWLEDGEMENTS

We sincerely acknowledge the technical assistance rendered by Dr. Madhavi Sunitha, Mr. Eswara Reddy, M and Mr. Augustine, KJ during the conduct of different tests and Mr. Sairam, V for his guidance in yoga training to the subjects.

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