

How Effective Is Sun Salutation in Improving Muscle Strength, General Body Endurance and Body Composition?

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Abstract

Purpose: The purpose of the present study was to evaluate effects of regular practice of sun salutation on muscle strength, general body endurance and body composition.

Methods: Subjects (49 male and 30 female) performed 24 cycles of sun salutation, 6 days a week for 24 weeks. Upper body muscle strength was determined by 1 repetition maximum (1RM) for bench press and shoulder press technique. Back and leg dynamometry was used to assess strength of back and leg muscles. General body endurance was evaluated by push-up and sit-up tests. Body composition was assessed by noting % body fat by using bioelectric impedance analysis. Perceived intensity of exercise by subjects was noted by Borg scale.

Results: Muscle strength by bench press showed significant increase in male (29.49 ± 9.70 to 36.12 ± 9.09 Kg, $P < 0.001$) and female (10.5 ± 4.42 to 13.16 ± 4.44 Kg, $P < 0.001$) subjects. Strength by shoulder press also increased (males; 22.96 ± 9.57 Kg to 26.53 ± 11.05 Kg, $P < 0.001$, females; 6.83 ± 2.78 to 8.83 ± 3.87 , $P < 0.001$). Endurance by push-ups & sit-ups showed similar findings in male (19.0 ± 9.58 to 21.98 ± 8.98 , $P < 0.001$ and 24.92 ± 10.41 to 29.84 ± 12.64 , $P < 0.001$ respectively) and female (14.66 ± 6.80 to 18.56 ± 6.97 and 13.16 ± 7.75 to 19.23 ± 8.25 , $P < 0.001$ respectively) subjects. A significant decrease in body fat percent was observed only in female (27.68 ± 5.46 to 25.76 ± 4.72 , $P < 0.001$) but not in male subjects. BMI significantly decreased in both the groups ($z = 4.37$, $P < 0.001$ and $t = 5.41$, $P < 0.001$ respectively).

Conclusion: From our observations we conclude that sun salutation can be an ideal exercise to keep oneself in optimum level of fitness.

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INTRODUCTION

The need of the 21st century is not only to achieve medical excellence in curing the patients but also and perhaps more importantly to prevent people from becoming sick. At present, a major cause of morbidity and mortality is modern lifestyle which includes stress, physical inactivity and high fat diet leading to obesity. These factors manifest themselves as lifestyle diseases such as hypertension, diabetes mellitus and coronary artery disease^[1,2].

In Indian culture, yoga has traditionally been a part of daily routine which is meant for attaining healthy life. *Ashtang* yoga, as described by *Maharishi Patañjali*, comprises of 8 stages viz. *yam* (code of conduct, self-restraint), *niyam* (religious observances, commitments to practice, such as study and devotion), *asana* (integration of mind and body through physical postures), *pranayam* (regulation of breath leading to integration of mind and body i.e. controlled breathing), *pratyahar* (abstraction of the senses, withdrawal of the senses of perception from their objects), *dharana*

(concentration, one-pointedness of mind), *dhyana* (meditation) and *Samadhi* (the quiet state of blissful awareness, superconscious state). Sun salutation, also called as *Suryanamaskar*, sun adoration for health, efficiency and longevity is a part of Indian traditional yogic practices [3]. It involves pranayam, asana and upasana i.e. rituals. The sun salutation is performed as a cyclical event synchronized with a specific breathing pattern. Each cycle consists of 10 steps performed consecutively one after the other. The cycle begins with *Stithi* or *Pranamasana*; the prayer posture. It is then followed by the following steps in a sequence. Step 1- *Hasta Uttanasana*, step 2- *Padahastanasana*, Step 3- *Dakashinpad Prasarnasan*, Step 4- *Dwipad Prasarnasan*, Step 5- *Saashtang Namasakarasan*, Step 6- *Bhujangasan*, Step 7- *Parvatasan* Step 8- *again Dakashinpad Prasarnasan*, Step 9- *Padahastanasana* and Step 10- coming back to *Stithi*. These individual asanas have their own physical benefits [3] e.g. Step 0 and 10 in figure 1 induces a state of introversion; Step 1 stretches thoracic, abdominal and intestinal muscles and lifts prana upwards in the body. Step 2 and 9 massages the abdominal organs, tones the spinal nerves and moves prana in lower body parts. Step 4 and 5 tone abdomen, muscles of thighs and legs. Step 6 exercises the spine and strengthens muscles of arms and legs.

Step 7 strengthens the muscles of shoulders, arms and chest. All these postures are arranged in such a way that each step is complimentary to the other. As an example backward bending alternates with forward bending. Thus sun salutation becomes a kind of activity which involves almost every part of the body and is considered as a complete exercise. Many of sun salutation practitioners also believe that regular practice of few cycles, when performed properly leads to development and strengthening of almost every part of the body [4]. Hence, the present study was designed to evaluate changes in muscle strength, general body endurance and body composition with regular practice of sun salutation.

METHODS AND SUBJECTS

Participants:

The experimental design was sequential self-control study which was conducted between January 2009 and September 2009. Eighty eight medical undergraduate students voluntarily enrolled in the present study. Those having a history of active sports training, yoga



Fig. 1: Steps involved in sun salutation. 0/10: *Stithi/ Pranamasana*, 1: *Hasta Uttanasana* 2 and 9: *Padhastasan*, 3 and 8: *Dakashinpad Prasarnasan*, 4: *Dwipad Prasarnasan*, 5: *Saashtang Namasakarasan*, 6: *Bhujangasan*, 7: *Parvatasan*

practice, and medical illness such as, hypertension, diabetes mellitus, bronchial asthma, tuberculosis or major surgery in the recent past were excluded from the study. Informed written consent was obtained from the participants after explaining them the purpose of the study, testing procedures and sun salutation training schedule. The study protocol was approved by the institutional research council and ethics committee.

Seventy nine subjects (49 males and 30 females) completed the study protocol. Reasons for dropout included transfer to other institutes (n=4), medical problems (n=2), and irregular participation in the training schedule (n=3).

Procedure:

Sun salutation training: Sun salutation training was imparted to the subjects by a trained yoga instructor as per the guidelines of Yoga Vidya Dham, Nashik Maharashtra, India. Practice sessions were held between 5.00 p.m. and 6.00 p.m., Monday through Saturday, for a duration of 24 weeks. Each session began with a prayer followed by *Omkar* chanting with appropriate 'Bija mantra' for each sun salutation and the session ended with prayer and *shavasana*. Subjects performed 6 cycles of sun salutation on the 1st day and the number was gradually increased to 24 over the next 15 days. This daily practice of 24 cycles of sun salutation was then performed for 6 days a week and continued for 24 weeks. Subjects in the study group were required to attend at least 80% of sessions to be considered in the study analysis.

Experimental protocol: All the tests were done under standard laboratory conditions after familiarising the subjects with testing procedure. Vital data including name, age (17.5-20 years), sex, height and weight of the subjects were recorded. Height was measured to the nearest 0.1 cm by using a standard stadiometer. In all subjects, the parameters described below were assessed before the beginning of sun salutation practice and after the 24 weeks of regular practice of sun salutation.

Upper body muscle strength: It was assessed by the one repetition maximum (1RM) technique for bench press and shoulder press exercises^[5,6]. The 1-RM is defined as the maximum resistance a subject can overcome, using correct form, through a full range of motion, for no more than one repetition. All the subjects were

asked to lift the light weights to learn proper technique and minimize muscle soreness for 1 week. After the 1 week of familiarization, the tester selected a light weight and asked the subject to perform the lift. A rest period of 4 minutes was given and the process was repeated with a heavier weight. With adequate rest periods, the process was continued till 1RM was obtained. The maximum weight in kg that could be lifted perfectly through only one repetition was noted as the strength. Bench press technique was used to assess pectoralis strength whereas shoulder press technique was used to assess strength of triceps and deltoids.

Lower body muscle strength: This was assessed by using a back and leg dynamometer (Anand Agencies Pvt. Ltd. Pune)^[5].

Subject was asked to stand on the platform of the instrument with knees flexed at 45 degrees and was instructed to keep the back straight. The position of the rod to be pulled was adjusted so that it could be held with extended arms at the level of thigh. Then the subject was asked to pull the rod upwards just by knee extension with his full force. The reading on the dial to the nearest 1 kg was recorded as the lower body muscle strength. (Fig. 2)

With the back and leg dynamometer strength of the back muscles was found out as follows: Subject was asked to stand with his knees extended and hip flexed at 45 degrees. Position of the rod was adjusted at knee level and he was asked to pull the rod by extending his back. The amount of force generated in kg was noted. (Fig. 3)

General body endurance: It was evaluated by push-up and sit-up tests^[5]. Maximum number of push-ups and sit-ups which could be performed with the rate of 20/min was recorded.

Body mass index (BMI): It was calculated from the height and weight measurements by using the formula: $BMI = \text{Body weight (kg)} / \text{Height}^2 (\text{m}^2)$

Body composition: Body fat percent was estimated with the help of bioelectrical impedance analysis (Citizen body fat analyzer BM100, Citizen systems Japan, Co. Ltd., Tokyo). In this method a small alternating current is passed through the body and the resistance offered to the current is noted. This in turn is related to body fat percentage based on height, weight,

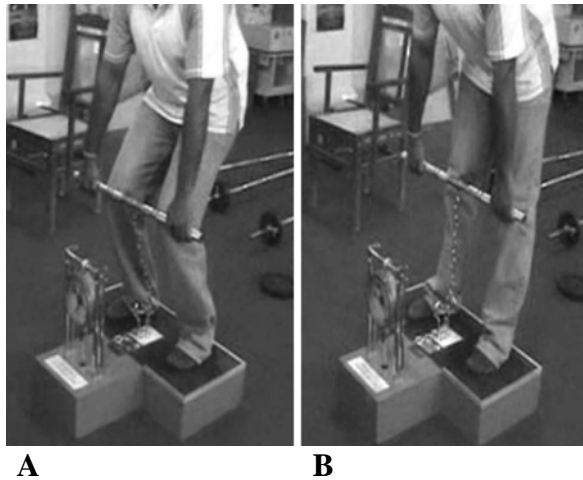


Fig. 2: Leg dynamometry A) Starting position B) Final position

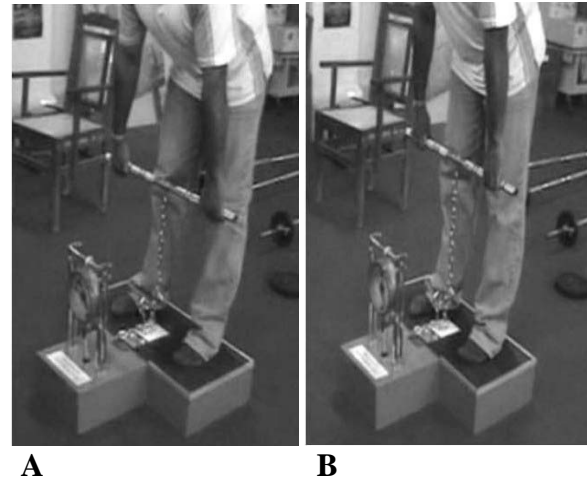


Fig. 3: Back dynamometry A) Starting position B) Final position

age and sex of the subject. This method is considered valid and reliable to measure resistance in biological tissues [7]. From percentage of body fat, percentage of lean body mass was calculated.

Perceived level of exertion: Immediately after the session, the subjects rated the intensity of exercise by Borg scale for rating of perceived exertion (RPE) [8]. In this scale, the exerciser rates his perceived feelings about the exertion level on a numerical scale ranging from 6-19 i.e. from very, very light to very, very hard.

Statistical analysis:

Data was analysed by NCSS97 software and expressed as mean \pm SD. Paired t test was used to compare the values in male and female subjects separately with α value of 0.05. Wilcoxon Signed-Rank test was applied to the data which was not normally distributed. Differences in means were considered statistically

significant when the two-tailed P value was < 0.05 . Also percent changes in all the parameters in both the groups were found out. Unpaired t test and Mann-Whitney U test was applied to test the significance between the groups with α value of 0.05.

RESULTS

In the present study, we found that with regular practice of sun salutation, there was statistically significant improvement in muscle strength and general body endurance in male as well as female subjects (Table 1 and 2). Upper body muscle strength as assessed by bench press method showed statistically significant improvement in male and female subjects.

Table 1: Changes in muscle strength and general body endurance with regular practice of sun salutation in male subjects (N=49)

Parameter	Before [Mean (SD)]	After (Mean \pm SD)	95% CI (difference in mean)	T value	P value
Bench press (Kg)	29.49 (9.70)	36.12 (9.09)	5.31_7.96	10.07	<0.0001
Shoulder press (Kg)	22.96 (9.57)	26.53 (11.05)	2.29_4.85	5.62	0.0001
Leg dyna-mometry (Kg)	116.45 (12.35)	122.12 (14.10)	2.79_8.55	3.97	0.0002
Back dyna-mometry (Kg)	111.43 (18.18)	115.67 (17.45)	1.01_7.48	3.09*	0.002
Push ups	19.0 (9.58)	21.98 (8.98)	1.52_4.44	3.82*	0.0001
Sit-ups	24.92 (10.41)	29.84 (12.64)	3.21_6.63	4.58*	0.0005

* Z value by Wilcoxon Signed-Rank test; SD: Standard Deviation; CI: Confidence Interval

Table 2: Changes in muscle strength and general body endurance with regular practice of sun salutation in female subjects (N=30)

Parameter	Before [Mean (SD)]	After (Mean ± SD)	95% CI (difference in mean)	T value	P value
Bench press (Kg)	10.5 (4.42)	13.16 (4.44)	1.72_3.61	3.99*	<0.0001
Shoulder press (Kg)	6.83 (2.78)	8.83 (3.87)	0.95_3.05	3.89	0.0005
Leg dyna-mometry (Kg)	62.06 (14.68)	72.07 (13.44)	7.45_12.55	4.75*	<0.0001
Back dyna-mometry (Kg)	61.93 (15.40)	69.00 (13.16)	4.21_9.93	4.52*	<0.0001
Push ups	14.66 (6.80)	18.56 (6.97)	3.26_6.48	4.59*	<0.0001
Sit-ups	13.16 (7.75)	19.23 (8.25)	4.48_7.65	7.83	<0.0001

* Z value by Wilcoxon Signed-Rank test; SD: Standard Deviation; CI: Confidence Interval

Muscle strength by shoulder press was increased in males ($t=5.62$, $P<0.001$) and females ($t=3.89$, $P<0.001$). Lower body muscle strength and back muscle strength also showed significant improvement in males and females. General muscle endurance as tested by push-ups and sit-ups improved in males and females.

As shown in table 3 and 4, body weight and body mass index (BMI) were reduced in both male and female subjects. Decrease in % body fat was significant in female subjects only but not in male subjects. Lean body mass (LBM) was increased in both the groups but the change was significant only in female subjects.

As shown in table 5, more improvement was observed in female subjects than their male counterparts for all parameters. Mann-Whitney U test for unequal variances was applied for statistical analysis. Improvement in two groups was significant ($P<0.05$) for back and leg strength, endurance by sit-ups and lean body mass. Sun salutation session was rated 11 on the RPE (Borg) scale by male subjects which is equivalent to about 50% of VO_{2max} exercise intensity whereas for female subjects RPE was 1 which corresponds to 75% of VO_{2max} .

DISCUSSION

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The hypothesis of the present study was regular practice of sun salutations improves muscle strength, endurance and body composition. In this study we revealed a statistically significant increase in upper as well as lower body muscle strength in both male and female groups. The physiologic responses to physical training and yogic practices have been well studied^[9]. Yoga training is associated with improvement of muscle strength and respiratory endurance^[10]. Earlier studies also noted a statistically significant increase in lower body strength with 8 weeks of yoga practice in informal caregivers; as evaluated by chair stand test^[11]. Similar results were found by the other researchers with yoga practice^[12,13]. During sun salutation, muscles of the entire body experience stretch and pressure alternately and therefore it is said to give more benefits in short duration of time^[4,14]. Many of its poses build strength because they require sustained contractions of many muscle groups of the entire body, which is comparable to resistance training^[15]. In the present study, more improvement is observed in strength of upper body than lower body. This might be because of

Table 3: Changes in body composition profile with regular practice of sun salutation in male subjects (N=49)

Parameter	Before [Mean (SD)]	After (Mean ± SD)	95% CI (difference in mean)	T value	P value
Height (m)	1.70 (0.04)	1.70 (0.04)	-0.27_ (0.27)	1.55*	0.12
Body weight (Kg)	61.92 (11.36)	60.21 (10.60)	-2.25_(-1.01)	5.29	<0.0001
Body mass index (Kg/m²)	21.43 (3.91)	20.87 (3.61)	0.35_078	4.37*	<0.0001
Body fat (%)	18.84 (6.29)	18.42 (5.56)	-0.27_1.12	1.87*	0.06
Lean body mass (%)	81.16 (6.29)	81.58 (5.56)	-1.12_0.27	1.83*	0.07

* Z value by Wilcoxon Signed-Rank test; SD: Standard Deviation; CI: Confidence Interval

Table 4: Changes in body composition profile with regular practice of sun salutation in female subjects (N=30)

Parameter	Before	After	95% CI (difference in mean)	T value	P value
	[Mean (SD)]	[Mean (SD)]			
Height (m)	1.55 (0.05)	1.55 (0.02)	-1.05_4.59	1.88	0.07
Body weight (Kg)	53.82 (9.06)	52.27 (8.33)	1.002_2.097	5.79	<0.0001
Body mass index (Kg/m ²)	22.41 (3.88)	21.76 (3.64)	0.49_1.11	5.41	<0.0001
Body fat (%)	27.68 (5.46)	25.76 (4.72)	1.31_2.54	6.38	<0.0001
Lean body mass (%)	72.32 (5.46)	74.24 (4.72)	-2.54_(-1.31)	6.37	<0.0001

SD: Standard Deviation; CI: Confidence Interval

more utilization of upper body muscles for weight bearing during the stages viz. 4, 6, and 7 of sun salutation.

General body endurance depends on skeletal muscle characteristics, oxygen uptake, its circulation and utilization. Performing sun salutation is similar to aerobic exercise as it involves static stretching and slow dynamic component with optimal stress on cardio-respiratory system [16]. Incorporating sun salutation in a yoga session contributes to significantly intense physical activity to improve cardio-respiratory fitness in unfit or sedentary individuals [17]. Yogic practices increase muscle strength, oxygen uptake, its circulation and utilization [12,18]. With increase in these parameters, sun salutation practice leads to improvement in general muscle endurance.

In the present study, sun salutation practice has led to decrease in body weight and % body fat and increase in % lean body mass. Yoga practices lead to increase in energy expenditure resulting in statistically significant changes in body composition [19,20]. Practice of only

hatha yoga for 30 min a day increased MET to 2.5 in females. (MET is multiple of resting metabolic rate. 1 MET= oxygen uptake of 3.5 ml/kg/min) But inclusion of sun salutation in the session increased the MET to 3.74 [21]. Thus sun salutation incorporates a significant aerobic component to the yoga activity. This fact is reflected in the change of body weight and body fat percent. However, the changes in % body fat and LBM were statistically significant in females but not in male subjects. Body composition also depends on the diet. In our study no specific change was suggested in the diet pattern and the subjects continued their routine diet. Our subjects were undergraduate students and about 84% of them were residing in a hostel. In our own but unpublished study, we have noted that male students residing in hostel consume more junk food and that may be the cause for little change in their body composition.

Also the sun salutation training was perceived by the male subjects as 'fairly light' activity (RPE 11) whereas the same was perceived by female subjects as

Table 5: Percent change in before and after values of different parameters in male and female subjects following sun salutation

Parameter	% Change		95% CI (difference in mean)	z value*	P value
	Male	Female			
Bench press	22.49	25.33	-22.77_9.06	-0.05	0.9
Shoulder press	15.56	29.28	-36.26_3.91	0.07	0.9
Leg dynamometry	4.87	16.11	-19.55_(-6.93)	4.15	<0.0001
Back dynamometry	3.81	11.42	-17.42_(-2.13)	2.10	0.03
Push-up	15.68	26.6	-68.97_2.87	1.38	0.2
Sit-up	19.74	46.13	-71.06_-21.65	3.33	0.0009
Body weight	-2.64	-2.88	-1.17_1.69	-0.65	0.5
BMI	2.44	3.29	-2.40_0.69	1.26	0.2
% Body fat	-2.25	-6.95	1.00_11.75	-1.45	0.1
% LBM	0.52	2.66	-3.34_(-0.92)	3.21	0.001

* Mann-Whitney U test; SD: Standard Deviation; CI: Confidence Interval

'somewhat hard' activity (RPE 14). Possibly an exercise of higher intensity is required to bring about significant changes in body composition of male subjects.

In our study we also observed that, for all parameters, females showed better improvement than males. This might be due to their lower baseline physical fitness than males which provided more scope for the improvement.

The present study was restricted to college students aged from 17.5 to 20 years. Future studies can be performed on healthy but middle aged and elderly populations. In addition, sun salutation needs to be further investigated as a tool to enhance physical fitness and quality of life dimensions in various diseased conditions.

CONCLUSION

Results of the present study indicate that sun salutation has the potential to improve the muscle strength, general body endurance and body composition to the optimum level in healthy individuals. These components in turn, enhance an individual's physical

fitness. Sun salutation does not require any tools or gadgets, limited space is enough to perform them and only a few minutes are necessary to perform a given number of cycles. Generally, resistance training which improves muscle strength and aerobic exercises which improve body endurance and body composition are believed to be the essential components of a fitness regimen. However, from the present study, it can be concluded that sun salutation is an easier and less time consuming alternative to improve strength, body composition and general body endurance.

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Conflict of interests: None

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