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Effect of a structured Bihar model suryanamaskar intervention on lipid metabolism and body composition in middle adulthood

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Abstract

Introduction: Dyslipidemia and abnormal body composition are major risk factors for cardiovascular disease, especially in middle-aged women who experience metabolic and hormonal changes. Surya Namaskar is a dynamic yogic sequence that combines aerobic, musculoskeletal, and psychophysiological advantages. The present study investigated the effect of Bihar Model Surya Namaskar on the lipid profile and body composition of women aged 37-52 years.

Methodology: A pre-post experimental design was adopted, in which a total of 40 female participants were divided into experimental and control groups in equal numbers. The experimental group went through a standardized 30-day Surya Namaskar protocol consisting of loosening exercises, Parvatasana-based sequences, functional movements, relaxation practices, and deep breathing, one hour daily. Lipid parameters (Total Cholesterol, Triglycerides, LDL, VLDL) and body composition measures (Weight, BMI, Waist and Hip Circumference) were measured on Day 0 and Day 31. Because the data were not normally distributed, the required analysis was done using the Wilcoxon Signed-Rank Test and the Mann-Whitney U Test, with a level of significance of less than 0.05.

Results: There were statistically significant reductions in all variables after 30 days in the experimental group: Total Cholesterol ($p = 0.001$), Triglycerides ($p = 0.001$), LDL ($p = 0.001$), VLDL ($p = 0.001$), Weight ($p = 0.001$), BMI ($p = 0.001$), Waist Circumference ($p = 0.0001$), and Hip Circumference ($p = 0.001$). In contrast, the control group showed nonsignificant increases in all parameters. Further, between-group comparisons showed that the experimental group had significantly lower post-test values than the control group in all the outcomes tested ($p < 0.05$). The results confirm that Surya Namaskar has a positive effect on lipid metabolism and body composition.

Conclusion: The results of the 30-day Bihar Model Surya Namaskar intervention indicate its efficacy in reducing dyslipidemia-related markers and improving anthropometric measures among middle-aged women. Safe, accessible, and non-pharmacological in nature, Surya Namaskar holds immense metabolic benefits, thus justifying its inclusion in lifestyle modification and preventive health programs.

Keywords: Surya Namaskar, lipid profile, body composition, middle-aged women, lifestyle intervention, cardiovascular risk reduction, metabolic health

Introduction

Dyslipidemia denotes as abnormal lipid levels in the blood, elevating the risk of cardiovascular diseases. It encompasses high total cholesterol, low-density lipoprotein (LDL) cholesterol, triglycerides, or low high-density lipoprotein (HDL) cholesterol levels and primarily caused by genetic factors, lifestyle choices (like poor diet and lack of exercise), obesity, certain medical conditions (such as diabetes and hypothyroidism), and medications [31]. It is identified by elevated [6] triglyceride levels (≥ 150 mg/dL), increased low-density lipoprotein (LDL ≥ 130 mg/dL), and reduced high-density lipoprotein (HDL < 40 mg/dL [29]. These lipid abnormalities are associated with an augmented risk of cardiovascular diseases, insulin resistance, kidney and liver diseases, polycystic ovary syndrome (PCOS) and certain medications including diuretics, beta-blockers, corticosteroids, and antiretroviral drugs can also impact this condition. The build-up of fats in blood vessels is due to a process called atherosclerosis and accumulation over time leads to inflammation, oxidative stress, and increasing the risk of

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cardiovascular diseases, which includes the collection of cholesterol, triglycerides & other substances on the inner walls of arteries, high level of triglycerides also responsible for a rare condition as pancreatitis [38]. With time, these plaques can constrict and harden arteries, reducing blood flow and heightening the chance of cardiovascular issues. Physiologically, this process induces inflammation, oxidative stress, and harm to blood vessel walls, exacerbating the accumulation of fats and cholesterol in the arteries. [1] It is a condition which doesn't show signs or symptoms, as by time the condition worsens which leads to CHD, peripheral arterial disease, angina & dyspnea [7, 35]. Total cholesterol refers to the overall measurement of cholesterol in the blood, including both high-density lipoprotein (HDL) cholesterol ("good" cholesterol) and low-density lipoprotein (LDL) cholesterol ("bad" cholesterol), as well as very-low-density lipoprotein (VLDL) and other lipid components. This measurement is commonly used to assess cardiovascular risk, with high levels of total cholesterol, especially LDL cholesterol, being associated with an increased risk of heart disease and stroke [31, 7]. The Non-Communicable Disease Risk Factor Collaboration and Global Burden of Diseases Studies indicate a surge in LDL and NHDL cholesterol levels in India [31]. Elevated levels of blood cholesterol are linked to increased risks of developing cardiovascular diseases such as stroke, peripheral vascular disease, and coronary heart disease (CHD) [7]. Maintaining high levels of blood cholesterol can significantly raise the likelihood of experiencing these serious health conditions. According to the Global Burden of Disease (GBD) Study, death rates from coronary artery disease (CAD) are decreasing in most developed nations but are on the rise in India, as well as several developing countries in South Asia and Africa [16]. This trend highlights a concerning disparity in cardiovascular health outcomes between regions. The prevalence of dyslipidemia ranged from 64.3% to 89.3% among males and females in Chennai, Delhi, and Karachi [8]. Studies shown that, among both genders, women exhibit a slightly higher susceptibility to lipid abnormalities within this range. Research indicates that individuals of Indian descent and migrant Asian Indians exhibit higher levels of triglycerides and lower levels of HDL cholesterol in their blood compared to Western populations [4]. Kerala, Punjab, and Tamil Nadu have the highest rates of cardiovascular disease (CVD) compared to other states [16, 15]. For factors such as hormonal changes, smaller coronary arteries and the differences in the fat distribution makes the women more vulnerable to the negative effects of high cholesterol and gives the importance of gender-specific consideration [13]. It is alarming that cardiovascular diseases primarily impact the most productive age groups, typically aged 35 to 65 years and observed more prevalence of lipid abnormalities in the younger age group [12, 13]. Body composition values like weight, Body mass index, Hip circumferences and Waist circumferences are the secondary signs of the fat deposition in the body, where it can also be an early sign to find the condition [13].

BMI is said to be the Body Mass Index, which is widely used as an anthropometric measurement. It evaluates the relationship between an individual's body weight and height values. It is calculated by dividing the body weight in kilograms by the height in square meters (kg/m²). The value will serve as an indicator of body fat and categories as underweight, normal weight, overweight, Obese class I, Obese class II & Obese class III.

<18.5 - Underweight

18.5 - 24.9 Normal weight
25.0 - 29.9 Overweight
30.0 - 34.9 Obesity Class I
35.0 - 39.9 Obesity Class II
≥ 40.0 - Obesity Class III (Severe)

Hip circumference is a value of body composition, where the measurement taken around the widest portion of the buttocks and increased fat deposition in the gluteal and pelvic regions also an indicator of overweight.

Waist circumference is measurement, which is taken around the abdomen at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest, where the measurement ≥ 88 cm is a solid indicator for Central Obesity.

Yoga has been shown to effectively reduce cholesterol levels, offering a natural and holistic approach to improving heart health and lowering the risk of cardiovascular disease [19, 20].

Loosening the joints are given as type of body warm up, to help the joints to loosen up before the yoga practices. Pawanamuktasana series are exclusively for the loosening of joints where it improves the coordination, stretches the ligaments and tendons, which serves as a warmup before the yoga practice handpicked joint exercises are taken from the pawanamuktasana series 1 and given as the warmup before the yoga practice [30].

Wall twist (Standing) is a type of exercise, where the rotational movement enhances the trunk mobility in the frontal plane [21]. It engages the core muscles effectively, leading to structural changes in the trunk area.

Abdominal exercises have been proven to increase muscle endurance [37]. It also shows that engaging in trunk rotation exercises can effectively stimulate the core muscles [36, 9].

Thus, it may conclude that abdominal aerobic endurance exercise on abdominal exercises effectively reduce abdominal fat and resulted in a greater level of muscle activation [3].

Knee clap has treated as circuit movement, where the Research published in Medicine & Science in Sports & Exercise revealed that women participating in high-intensity interval training, featuring exercises such as the knee clap, experienced notable reductions in visceral fat compared to those engaging in low-intensity workouts. Research published in Frontiers in Physiology indicates that circuit training, which can incorporate exercises like knee claps, is effective in reducing abdominal subcutaneous fat tissue depot. Surya namaskar is basically known as the Sun salutation, which comprises of 12 asanas in a series [40]. It was Bhawanrao Shrinivasarao Pant Pratinidhi who provided a book, which states the early processing of SN [25] and then evidently recorded in the early 20th century with a lot of variations [17].

From all of the variations, the one with parvatasana series was mentioned in the -The Ten-point way to health - book [25] and in the Bihar model school of yoga also follows the same variation involving the Parvatasana [30]. Due to the presence of parvatasana the BSY model is better than other variations of SN, where the asana exerts more pressure on the arms and legs rather than in abdomen as it is way more similar to Adhomuka Svanasana [14]. Thus, it creates a lower strain on the abdomen, which makes the practitioner perform more rounds of the SN than the other variations of Surya namaskar. This dynamic sequence of asanas helps to improve blood circulation, strengthen and tone the muscles through coordinated forward and backward bends, increase flexibility, and activate the internal organs [10, 28]. Previous research and practical observations have shown that regular practice of Surya Namaskar, a dynamic sequence of yogic postures, positively affects several health indicators such as lipid profile, body mass index (BMI), body weight, waist-hip ratio,

and body fat percentage [28, 27, 19, 11]. Asanas like Ashwasanchalasana, Bhujangasana Ashtanga namaskar does induce the upper trunk to increase its overall fitness [10]. It is also said to be a complete capsule of wellbeing especially for women throughout their all stages of life [24]. Chakkichalnasana is mentioned in the pawanamuktasana series 3, the energy block postures, which is mentioned in the book written by Swami Satyananda Saraswathi - Asana Pranayama Mudra Bandha [30]. The rotational movement of the upper trunk while maintaining torso stability engages the rectus abdominis, internal and external oblique, and transverse abdominis, enhancing core strength and muscle tone, which leads to the reduction in the abdominal fat^(5,32). Savasana is a supine type of asana which takes shorter time to recover from physiological exhaustion or stress by inducing the whole-body relaxation [33, 2]. It is Particularly effective after the dynamic practices such as Surya namaskar, which will induce the relaxation of the entire psycho-physiological system [33]. Deep breathing is a one of the breathing techniques which involves diaphragmatic breathing where deep inhalation and deep exhalation in low ratio of time period and a part in yogic breathing (Pranayama), which is the 4th limb in Ashtanga yoga by Sage Patanjali, it was first mentioned in Chandogya Upanishad and Bhagavad-Gita. It is used to restore the vagal flow, while reducing the stress [18] and relaxes the whole body and mind [39] by reducing the sympathetic activity and enhancing the baroreflex sensitivity. Recent evidence supports the effectiveness of yoga as a non-pharmacological intervention for improving lipid metabolism [20]. Researchers found that regular yoga practice led to reductions in total cholesterol, LDL, and triglycerides, alongside increases in HDL levels. Studies shows a significant decrease in the total lipid value due to practice of yoga which, supports yoga's role in improving lipid metabolism among CAD patients, adding to the rationale for integrating holistic mind-body interventions in cardiovascular disease management [23].

Objectives

1. To understand, the effect of yogic practices - Bihar model of Surya namaskar on lipid profile and Body composition variables among middle aged women.
2. To find, the influence of Surya namaskar on middle-aged women of 37 to 52 yrs.
3. To compare the change and difference between pre and post intervention in the experimental group and pre- and post-results of the control group without any intervention.

Null hypothesis: Ho- Bihar model of Surya namaskar will not show any significant reduction in the variables-lipid profile and Body composition variables on women aged 37 to 52years.

Alternative hypothesis (H1): Surya namaskar will have a significant effect on modifying the lipid profile and Body composition parameters in adult women.

Materials & Methodology

The current Study employs the following to determine the impact of Bihar Model of Surya namaskar on lipid profile and the Body composition values by using a pretest and posttest

design. 40 female subjects aged 37 to 52, collected according to the criteria and divided into 2 groups, experimental & Control groups each consists of 20 participants. The experimental group underwent 30 days of the training session (SN), while the control group followed their normal lifestyle without any interventions for the same duration. One hour of yoga practices were given to the experimental team by the researcher herself (Saraswathi mandapam) for 6 days/week and advised them to practice on the remaining day on their own. Dependent variables were documented on the 0th and 31st day from both groups, which later used as data to find the impact of SN by comparing the pretest & posttest of the experimental & control groups. An awareness session was conducted prior to data collection and informational pamphlets were distributed to explain the purpose, benefits and procedures of the experimental. Written informed consent was obtained from all participants before enrollment.

Variables

Independent variable

Bihar model of Suryanamaskar (loosening and aerobic movements are included)

Dependent variable

- Total cholesterol
- Triglycerides
- Low density lipoprotein (LDL)
- Very low-density lipoprotein (VLDL)
- Weight
- Body mass index (BMI)
- Waist circumference
- Hip circumference.

Inclusion Criteria

1. Women aged 37-52 years.
2. Borderline lipid profile levels.
3. BMI within the overweight range (25.0 - 29.9 kg/m²)
4. Non-smokers and non-alcoholics.
5. Not on any medication during the research period.

Exclusion Criteria

1. History of psychiatric medication use.
2. Premature or early menopause.
3. Uterine surgery, hysterectomy, or related surgical history.
4. Presence of any medical condition such as thyroid, use of steroid medicine etc.

Procedure

The experimental group were given training sessions from the 1st to 30th day, with 1 hour of daily practice by the researcher herself. Participants were assured to be on empty stomachs and empty bowels, while performing yoga. Yoga sessions were increased by overtime; progressive training schedule is introduced to the experimental team. The total duration of the Study was 31 days, consisting of 30 days of yoga intervention and one day for awareness and the 0th day provided awareness and interaction with the participants, including explaining the research objectives and procedures.

Loosening the joints (Pawanamuktasana series: 1)

Table I: Pawanamuktasana series I

Sl No.	Name	Procedure
1.	Neck up & down	Sit straight on the mat, where both palms firmly on the ground and feet together transmitting equal weight of the body. While inhaling, slowly stretch your neck back with eyes open and while exhaling bend your neck forward touching the chin with the jugular point.
2.	Neck rotation	Sit straight on the mat, where both palms firmly on the ground and feet together transmitting equal weight of the body. Eyes wide opened. Slowly rotate the neck to 360degree making a circle in a clockwise rotation and same repetition to the anticlockwise direction.
3.	Shoulder rotation	Sit straight on the mat, where both palms firmly on the ground and feet together transmitting equal weight of the body. Place both hands on the respective shoulder and rotate both shoulders at same time in clockwise direction and same repetition to anticlockwise direction.
4.	Elbow bend	Sit straight on the mat, where both palms firmly on the ground and feet together transmitting equal weight of the body. Bend both your elbows and place both palms on the respective shoulders. Inhale, stretch both elbows forward and exhale, bend it towards the shoulder as well.
5.	Wrist up & down	Sit straight on the mat, where both palms firmly on the ground and feet together transmitting equal weight of the body. Stretch both arms forward, where both palms face downward or to the floor. Up your both palms while stretching the wrist up. And slowly lower the palm downwards, where both palms face the individual herself.
6.	Wrist rotation	Sit straight on the mat, where both palms firmly on the ground and feet together transmitting equal weight of the body. Stretch both arms forward, where both palms face downward or to the floor. Make a fist in both palms. Rotate both palms in clockwise direction and rotate anticlockwise direction as well.
7.	Fingers tightening and stretching	Sit straight on the mat, where both palms firmly on the ground and feet together transmitting equal weight of the body. Stretch both arms forward, where both palms face downward or to the floor. Make a fist in both palms tight your fingers, where your thumb is enclosing the other 4 fingers
8.	Knee bend	Sit straight on the mat, where both palms firmly on the ground and feet together transmitting equal weight of the body. With the help of both your palms bent and hold your right feet close enough to your right chest. Release. Do the same to the left feet and of the same repetition.
9.	Half butterfly	Sit straight on the mat, where both palms firmly on the ground and feet together transmitting equal weight of the body. Bend your right feet towards the left inner thigh. Raise the right knee with right palm and slowly raise up and down. Do this with the left leg too.
10.	Ankle stretch	Sit straight on the mat, where both palms firmly on the ground and feet together transmitting equal weight of the body. Now slowly stretch your ankles upward and downwards.
11.	Rotation	Sit straight on the mat, where both palms firmly on the ground and feet together transmitting equal weight of the body. Rotate the ankles in clockwise and anticlockwise direction in the same repetition.
12.	Toe tightening	Sit straight on the mat, where both palms firmly on the ground and feet together transmitting equal weight of the body. Tight your toes and release.

Wall twist (Standing)

Procedure: Stand near a wall. Place both your heels and touch the end of the wall. Now place another leg to the exact measuring 1 foot from the wall. Head straight. Bending both your elbows were palms facing forward at the level of your shoulder. Now twist to the right and try to touch both palms on the wall where head neck feet are straight. And turn to the next left side and place both palms on the wall to make sure the whole body is straight where the abdomen, stomach and hip are exceptional from being straight. Do this like a continuous movement.'

Benefits

It helps to strengthen the body and enhance flexibility and balance. Helps to increase endurance by reducing fat and

increasing the core muscle strength.

Knee clap

Procedure: Stand straight, feet apart.

Raise your right and clap under the raised knee. Then stretch your arms up to the shoulder. Lower both your arms in such a way, where it can make a clap under the lifted knee. Place the lifted knee down to the floor and arms both are back to the shoulder level. This is one round, do this movement continues to the left and right knee.

Benefits: Reduce fat deposition around hip, waist, thigh. Enhance flexibility and mobility of the lower trunk.

Surya namaskar (Bihar model)**Table II: Surya namaskar (Bihar model)**

Sl No.	Name	Procedure
1.	Sthithi & Pranamasana	Stand straight head straight. Breath normally. Stretch both your arms up and make a Namaskar mudra (both palms are touching each other). Place it in the sternum region. Shoulder down.
2.	Hasta uttanasana	Stretch both your hands up and stretch a little back while looking at the fingernails.
3.	Padahasthasana	Bend forward with the arms glued with the ears. Touch the respective feet.
4.	Ashwasanchalasana	After bending forward to touch the feet. Place the right foot and place both palms on the floor align with the left foot, where the left side serves in the middle of both palms. Right feet should be flat. Look up and arch your back a little.
5.	Parvatasana	Place your left foot with the right foot to the back and sole of the feet on the ground. Both palms are placed on the front. Knee straight and push your body back, where it forms like a mountain pose.
6.	Ashtanga namaskar	Place your toes, knees, chest, palms and chin on the ground, where the hip is elevated up
7.	Bhujangasana	Rest your whole body down on the floor in prone and slowly place your respective arms between the shoulder and chest, feet together. Raise your upper body up to the navel and gaze up.
8.	Parvatasana	Elevate your hip up from the cobra pose where the head down and whole body are balanced on both palms and feet.
9.	Ashwasanchalasana	Place your right feet forward in between both palms, where left knee is on the ground and feet are flat. Look up.
10.	Padahasthasana	Place the left leg with the right leg and raise your hip to a standing motion and knees are straight, and palms are touching the feet.
11.	Hasta uttanasana	Raise both your palms and the upper body up and look at the fingernails.
12.	Pranamasana & Sthithi	Perform namaskar mudra in hands and place it near the sternum. Release the namaskar mudra and stand straight.

Savasana

Procedure: Lie on your back, where both feet and arms are apart facing upward and side respectively. Close your eyes and relax.

Benefits: promotes body awareness and facilitates mental calmness, attains complete relaxation, awareness of the mind is enhanced, fostering the state of pratyahara (withdrawal of the senses).

Chakkichalnasana

Procedure: Sit down, where both legs are stretched apart. Interlock your fingers and stretch your arm forward. No rotate in the form where the interlocked palms are touching both feet in a rotation. Like a grinding of rice. Do it for clockwise and anticlockwise direction.

Benefits: Core Strength and Tone, Spinal Mobility, Digestive Health, Fat Mobilization, Balance and Coordination toning the nerves and Organs of the pelvis and abdomen^[30]. It is very useful for Regulating the menstrual cycle.

Deep Breathing

Procedure: Sit in a cross leg, take a deep and slow inhale through both nostrils, where the thoracic region gets concentrated and without holding exhale through the nostrils as slow as possible. Both palms assumed in chin mudra as well.

Benefits: relaxes the mind, enhance the vagal flow^[18], enhance breathing capacity.

Training Sessions - 1st to 30th day**Table III:** Training Sessions on 1st day to 8th day

Sl No.	Yogic practice	Rounds / time
1.	Loosening exercises,	4 rounds each - 15 minutes
2.	Wall twist	30 rounds - 2 minutes
3.	Knee clap	20 rounds - 2 minutes
4.	Relaxation (Seated)	5 minutes
5.	Surya Namaskar - Bihar model	10 rounds - 15 minutes
6.	Savasana	5 minutes
7.	Chakkichalnasana (clockwise & anticlockwise).	15 + 15 rounds - 4 minutes. 1 minute in between both rotations.
8.	Relaxation (Seated)	5 minutes
9.	Deep breathing	6 minutes

Table IV: Training Sessions on 9th day to 19th day

Sl No.	Yogic practice	Rounds / time
1.	Loosening exercises,	4 rounds each - 15 minutes
2.	Wall twist	40 rounds - 2 minutes
3.	Knee clap	30 rounds - 2 minutes
4.	Relaxation (Seated)	5 minutes
5.	Surya Namaskar - Bihar model	12 rounds - 15 minutes
6.	Savasana	5 minutes
7.	Chakkichalnasana (clockwise & anticlockwise).	20 + 20 rounds - 4 minutes. 1 minutes in between both rotation
8.	Relaxation (Seated)	5 minutes
9.	Deep breathing	6 minutes

Table V: Training Sessions on 20th day to 30th day

Sl No.	Yogic practice	Rounds / time
1.	Loosening exercises,	4 rounds each - 15 minutes
2.	Wall twist	40 rounds - 2 minutes
3.	Knee clap	30 rounds - 2 minutes
4.	Relaxation -(Seated)	5 minutes
5.	Surya Namaskar - Bihar model	14 rounds - 14 minutes
6.	Savasana	5 minutes
7.	Chakkichalnasana (clockwise & anticlockwise).	30 + 30 rounds - 6 minutes. 1 minute in between both rotation
8.	Relaxation -(Seated)	5 minutes
9.	Deep breathing	5 minutes

Data Collection

The selected variables were collected before and after intervention from both groups, where the lip profiles were analyzed at Rajiv Gandhi Laboratory using 8 to 12 hours of fasting by blood sampling. The measurement of body composition was taken by the researcher herself to minimize inter-observer variability to assure reliability under standardized mode. Height - measured using Stadiometer in cm. Weight - taken by using a digital weight scale machine (participants advised to wear light clothes & no footwear) in kg. BMI - It was taken by calculating $wg/ht(m^2)$. Waist & Hip circumference - were assessed by using a non-stretchable

measuring tape and recorded in cm. Data were collected on the 0th and 31st day and systematically recorded on a pre-designed data collection sheet, and confidentiality of participants' information was strictly maintained.

Statistical Analysis

The data were systematically checked, coded and entered, where the detailed statistical analysis was done by using SPSS version 26.0. Due to non - normality data, Wilcoxon rank test is used to compare the paired data within the group and Mann Whitney U- test is used to compare the data between the control and experimental groups. The data were set in one

tailed test, 0.05 level of significance, where p value is 0.05, critical value is at 60 due to the N is 20. Tables and graphical representations such as bar diagrams were used to illustrate the changes in the measured variables to show the impact of the Surya namaskar (yoga practice).

Results: A total of 40 middle-aged women, $n = 20$ per group, Control group & Experimental group completed the 30-day intervention. Because of the sample sizes and non-normality of some variables, non-parametric tests were employed in all analyses. The Wilcoxon Signed-Rank Test was used to conduct within-group comparisons, while the Mann-Whitney U Test was used to perform between-group comparisons. The level of significance was $p < 0.05$ (one-tailed).

Within-Group Analysis - Experimental Group: Table VI &

Table VI: Wilcoxon Signed-Rank Test Results of the Experimental Group

Sl no.	Variables	Test	N	Median	T-	P value
1.	Total cholesterol (tch)	Pre	20	223.8	5	.001
		Post	20	213		
2.	Triglycerides (tri)	Pre	20	159	14.5	.001
		Post	20	155		
3.	LDL (ldl)	Pre	20	151.10	2.5	.001
		Post	20	142.20		
4.	VLDL (vldl)	Pre	20	31.80	11.5	.001
		Post	20	30.60		
5.	Weight (wg)	Pre	20	64.50	1	.001
		Post	20	62.45		
6.	BMI (bmi)	Pre	20	26.80	1	.001
		Post	20	25.95		
7.	Waist circumference (wc)	Pre	20	96.65	0	.0001
		Post	20	91.9		
8.	Hip circumference (hc)	Pre	20	101.50	0	.001
		Post	20	98		

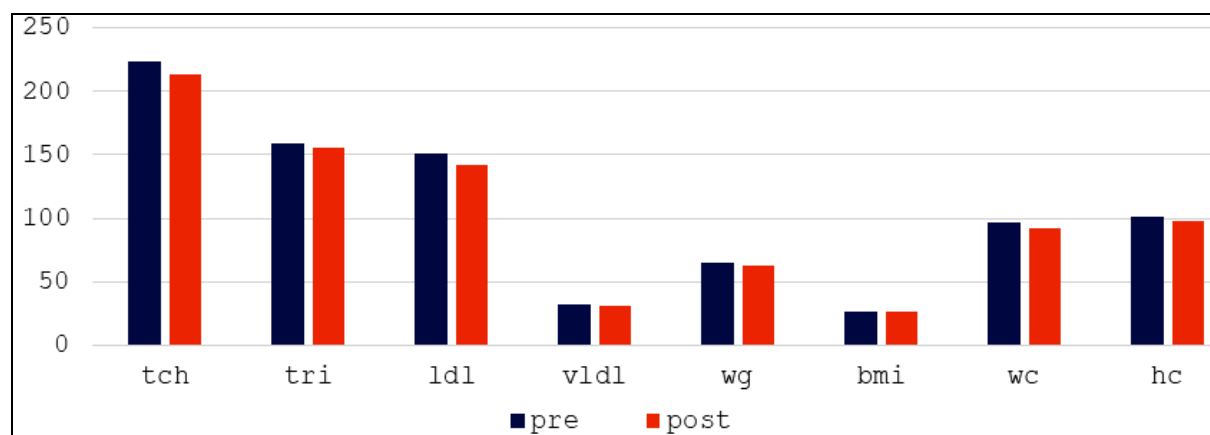


Fig I: Pre & Posttest median values of Experimental Group

Within-Group Analysis - Control Group

In contrast, Table VII & Fig II shows the control group showed no statistically significant changes across any variables. Instead, slight increases were observed in all lipid parameters—Total Cholesterol (216.90 → 219.15 mg/dL), Triglycerides (158.50 → 159.60 mg/dL), LDL (148 → 149.15 mg/dL), and VLDL (31.8 → 32 mg/dL)—although none

Fig I All the measured variables of the experimental group revealed a statistically significant reduction after the 30-day Surya Namaskar intervention. The parameters of the lipid profile showed an overall improvement, with median values diminishing for Total Cholesterol (223.8 → 213 mg/dL, $p = 0.001$), Triglycerides (159 → 155 mg/dL, $p = 0.001$), LDL (151.10 → 142.20 mg/dL, $p = 0.001$), and VLDL (31.80 → 30.60 mg/dL, $p = 0.001$). Similarly, there were significant decreases in the body composition variables: Weight (64.50 → 62.45 kg, $p = 0.001$), BMI (26.80 → 25.95 kg/m², $p = 0.001$), Waist Circumference (96.65 → 91.90 cm, $p = 0.0001$), Hip Circumference (101.50 → 98 cm, $p = 0.001$). These findings indicate that the Surya Namaskar protocol produced meaningful improvements in all biochemical and body composition variables.

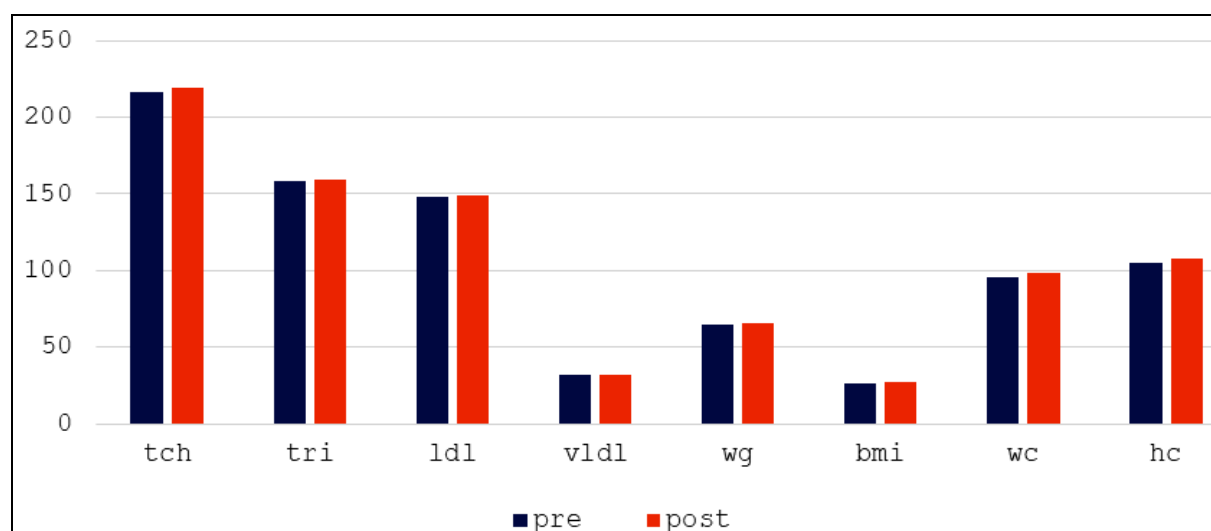
reached statistical significance ($p > 0.05$).

Body composition variables also demonstrated mild increases in Weight (64.50 → 65.70 kg), BMI (26.40 → 27.10 kg/m²), Waist Circumference (96 → 98 cm), and Hip Circumference (105 → 108 cm), again without statistical significance.

These unfavourable trends suggest natural progression toward worsening metabolic health in the absence of intervention.

Table VII: Wilcoxon Signed-Rank Test Results of the Control Group

Sl no.	Variables	Test	N	Median	T-	P value
1.	Total cholesterol (tch)	Pre	20	216.90	166	0.988
		Post	20	219.15		
2.	Triglycerides (tri)	Pre	20	158.50	172	0.988
		Post	20	159.60		
3.	LDL (ldl)	Pre	20	148	183	1
		Post	20	149.15		
4.	VLDL (vldl)	Pre	20	31.8	163	0.997
		Post	20	32		
5.	Weight (wg)	Pre	20	64.50	204	1
		Post	20	65.70		
6.	BMI (bmi)	Pre	20	26.40	203.5	1
		Post	20	27.10		
7.	Waist circumference (wc)	Pre	20	96	189	1
		Post	20	98		
8.	Hip circumference (hc)	Pre	20	105	190	1
		Post	20	108		

**Fig II: Pre & Posttest median values of Control Group****Table VIII: Mann Whitney U - Test Results of the in-between the Groups**

Sl no.	Variables	Group	Test	median	U	P
1.	Total cholesterol (tch)	Experimental	Post	213	107	0.006
		Control	Post	219.15		
2.	Triglycerides (tri)	Experimental	Post	155	79.5	0.001
		Control	Post	159.60		
3.	LDL (ldl)	Experimental	Post	142.20	100.5	0.003
		Control	Post	149.15		
4.	VLDL (vldl)	Experimental	Post	30.60	84.5	0.001
		Control	Post	32		
5.	Weight (wg)	Experimental	Post	62.45	118	0.013
		Control	Post	65.70		
6.	BMI (bmi)	Experimental	Post	25.95	95	0.002
		Control	Post	27.10		
7.	Waist circumference (wc)	Experimental	Post	91.9	52.5	0.001
		Control	Post	98		
8.	Hip circumference (hc)	Experimental	Post	98	38	0.001
		Control	Post	108		

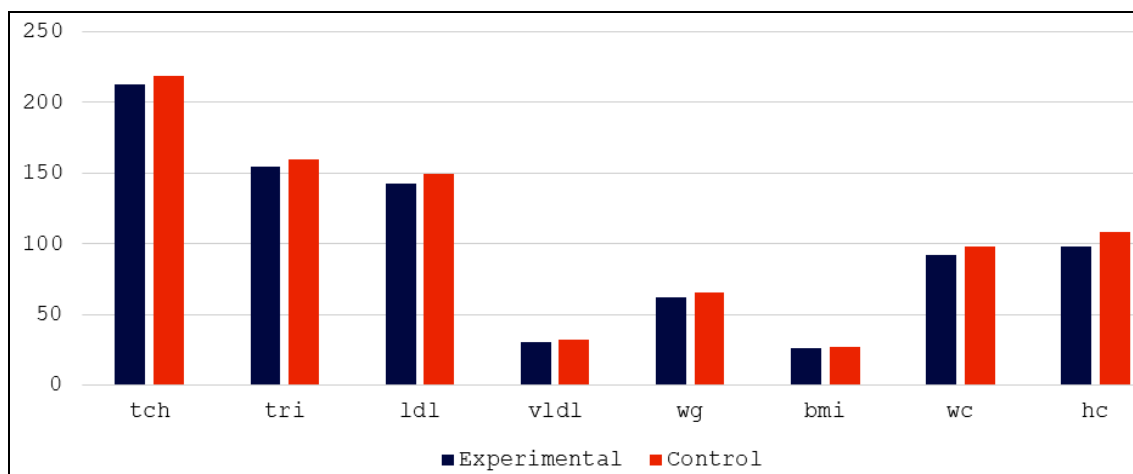


Fig III: Post test- Median values of Experimental and Control group (Variables)

Table III & Fig III shows that Mann-Whitney U test was conducted to compare the post-test scores of the experimental and control groups following a 30-day Surya Namaskar intervention. The values in the table: 3 clearly show that the values of the variables do get reduced due to the impact of the intervention of yoga. The analysis revealed statistically significant differences ($p < 0.05$) across all the measured variables, confirming the positive impact of yoga practice. Total cholesterol showed a significant reduction in the experimental group ($U = 107$, $p = 0.006$) when compared to the control group, indicating improved lipid metabolism, triglyceride levels decreased markedly among participants in the experimental group ($U = 79.5$, $p = 0.001$), suggesting better regulation of serum fats, low-density lipoprotein (LDL) levels ($U = 100.5$, $p = 0.003$) and very low-density lipoprotein (VLDL) levels ($U = 84.5$, $p = 0.001$), reflecting the hyperlipidemia effect of Surya Namaskar. Body weight significantly decreased in the experimental group compared to the control group ($U = 118$, $p = 0.013$), along with a corresponding reduction in body mass index (BMI) ($U = 95$, $p = 0.002$). Further, waist circumference ($U = 67.5$, $p = 0.001$) and hip circumference ($U = 62.5$, $p = 0.001$) also showed significant reductions, suggesting overall improvement in body composition and fat distribution among women who practiced Surya Namaskar regularly. The visual representation of the comparison between the median of posttest of experimental and posttest of Control to get a clear-cut idea, about how the reduction of the selected variables is clearly due to the intervention of Surya namaskar and yogic practices.

Discussion

The present investigation was designed to assess the effect of a 30-day Bihar Model Surya Namaskar intervention on lipid metabolism, body composition, and general well-being among middle-aged women. The results revealed that in the experimental group there were significant decreases in total cholesterol, triglyceride, LDL, VLDL, body weight, BMI, waist circumference, and hip circumference, while the control group had mild increases in all these parameters, which were not statistically significant. These findings indicate that Surya Namaskar, when performed regularly, provides a wide range of physiological, biochemical, and psychological benefits that together enhance metabolic health.

1. Physiological Response and Mechanistic Interpretation

Surya Namaskar integrates 12 dynamic postures with synchronized breathing and mindful awareness, producing a

distinctive form of aerobic-isometric training. The physiological mechanisms that contributed to improvements in the present study may be understood according to the following interrelated paths.

Cardiovascular and Metabolic Activation: The flexion-extension movements occurring alternately during Surya Namaskar stimulate the cardiovascular system.

- Increases heart rate
- Improving stroke volume
- Venous returns
- Peripheral circulation

This moderate-intensity aerobic load increases oxygen consumption and favors continuous fat oxidation.

Surya Namaskar increases skeletal muscle demand by enhancing glucose uptake via GLUT-4 transporters, improving mitochondrial respiration, and reducing circulating triglycerides, consistent with the biochemical improvements following intervention in the present study.

Autonomic Nervous System Regulation: Yogic movements with slow, rhythmic breathing induce parasympathetic activation and reduce sympathetic drive. Enhanced vagal tone is related to improved digestion, more stable lipid metabolism, reduction of cortisol output, and improvement in insulin sensitivity.

The deep breathing performed at the end of each session may have enhanced baroreceptor sensitivity, improved blood pressure regulation and indirectly contributing to better metabolic homeostasis. Such autonomic improvements are consistent with this work. Previous researchers are also found that slow breathing acutely improves vagal activity.

Musculoskeletal Engagement and Energy Demand: Most of the Surya Namaskar postures engage major muscle groups of both the upper and lower body. Weight-bearing postures—such as Parvatasana, Bhujangasana, and Ashwasanchalasana activates the muscles present in the abdomen region or core muscles such as:

- Rectus abdominis
- Transverse abdominis
- Obliques
- Back extensors
- Quadriceps and gluteal muscles

Hence, the postural asanas demand continuous muscular

contraction; thus, the muscle tone is improved, basal metabolic rate enhanced, and caloric expenditure increased. This accounts for the significant reduction in weight, BMI, and circumference measures in the experimental group.

Chakkichalnasana and knee-clap exercises most likely improve abdominal muscle endurance, trunk mobility, and local fat mobilization. Rotational movements tend to activate oblique muscles and improve core stability; postural improvements raise BMR, leading to reductions in abdominal fat.

2. Biochemical Improvements in Lipid Metabolism

The most striking results of the study included the significant reduction in lipid profile variables among the experimental group participants. A number of mechanisms potentially underpin these improvements.

Improved Lipoprotein Metabolism: Surya Namaskar activates enzymatic activities like

- **Lipoprotein lipase activity:** This enzyme helps in the breakdown of triglycerides. Lipoprotein lipase is activated, especially during Surya Namaskar, thus increasing the breakdown of circulating triglycerides into free fatty acids for energy production. Increased clearance of triglycerides results in reduced serum TG levels and contributes to better lipid metabolism.
- **Improvement in HDL function,** i.e., reverse cholesterol transport: Yoga metabolic activation enhances HDL's ability to transport excess cholesterol from peripheral tissues to the liver. This process of reverse cholesterol transport helps to reduce atherogenic plaque formation and improves cardiovascular health.
- **Fatty acid oxidation, reducing circulation LDL:** Dynamic yogic movements increase mitochondrial fatty acid oxidation, utilizing stored fats as an energy source. As more of the fatty acids are utilized for fuel, the liver releases fewer LDL particles, resulting in reduced levels of LDL in the blood.
- **Hepatic lipid regulation, lowering VLDL synthesis:** The habitual practice of Surya Namaskar reduces hepatic accumulation of triglycerides, thereby decreasing the secretion of VLDL from the liver. Lower VLDL synthesis contributes directly to an improved lipid profile and reduced cardiovascular risk.

Reduced Inflammation and Oxidative Stress: Chronic low-grade inflammation supports the process of dyslipidemia. Yogic practices reduce inflammatory markers, partly due to a decrease in cortisol levels and further due to reduced oxidative stress. Breathing practices increase nitric oxide production; this promotes vasodilation and reduces endothelial inflammation. Since oxidized LDL is the major contributor to atherosclerosis, the reduction in LDL in this study may reflect a decrease in lipid oxidation.

Improved Hormonal and Endocrine Regulation: Yoga is known to modulate the hypothalamic-pituitary-adrenal axis.

- Lower cortisol - Reduced sympathetic activations
- Improved insulin sensitivity
- Better thyroid function especially through upper-body extension postures, such as Bhujangasana

This plays a direct role in lipid synthesis and the accumulation of abdominal fat. Surya Namaskar also improves thyroid function through the stimulation of cervical and thoracic

regions by backbend postures like Bhujangasana and Hasta Uttanasana. Enhanced thyroid regulation supports metabolic efficiency and lipid utilization.

3. Changes in Body Composition and Structural Adaptations

The reduction in waist and hip circumferences in the experimental group points to the effectiveness of the intervention in reducing central and peripheral adiposity.

Reduced visceral fat accumulation: Visceral fat is metabolically active and strongly linked to dyslipidemia. The dynamic flow of Surya Namaskar improves.

- Blood flow to abdominal organs
- Improves lymphatic drainage
- Promotes fat mobilization.

Abdominal-focused practices, such as Chakkichalnasana, which tone the abdominal wall and stimulate digestive organs, also help reduce visceral fat.

Increased lean muscle mass and enhanced body composition - these were aided by the weight-bearing activities and dynamic nature of Surya Namaskar.

- Muscle hypertrophy
- Improved tone
- Increased energy expenditure

This supports the strengthening of muscles without any external equipment. Improved muscle mass increases resting metabolic rate, leading to better long-term bodyweight maintenance.

Increased Flexibility and Postural Alignment: Repetitive performance of asanas improves.

Spinal mobility

- Hamstring and hip-flexor flexibility.
- Range of motion
- Myofascial elasticity

Regular execution of Surya Namaskar and related asanas gradually enhances flexibility and postural alignment through improvement in spinal mobility, hamstring length, hip-flexor extensibility, and overall joint range of motion. Increased elasticity in the myofascial reduces mechanical impediments within the musculoskeletal system, enabling easier and more economical movement patterns throughout daily activities. This enhancement of flexibility reduces energy expenditure during physical tasks, increases exercise tolerance, and enhances functional mobility, indirectly benefiting metabolic regulation. As it becomes easier to move the body with less resistance, there is an increase in better utilization of calories, more effective oxygen delivery, and an overall rise in the level of physical activity, thus supporting long-term weight management and healthier lipid metabolism.

4. Psychological Benefits and Psychophysiological Influence

The practice of relaxation techniques such as Savasana and slow breathing has an essential influence on the improvement of psychological health, which influences physiological outcomes.

Reduced Stress and Cortisol Regulation: Stress-induced secretion of cortisol contributes to an increase in levels of lipids, deposition of abdominal fat, and disturbed metabolic

function. Psychological relaxation, brought about by Savasana and deep breathing (Pranayama), reduces:

- Cortisol level
- Anxiety
- Sympathetic activation
- Emotional eating habits

Overall, this activity stabilizes autonomic balance and engenders a feeling of calm. The participants reported that sleep quality was improved, less muscular tension, and increased emotional well-being.

Improved emotional regulation and mindfulness: It cultivates awareness of breath, posture, and body sensations. Improved mind-body connection:

- Reduces emotional eating
- Improves discipline in living habits
- Supports long-term adherence to healthy routines

These psychological shifts amplify the physiological benefits observed in lipid and body composition changes.

5. Yogic Science Perspective: Pranic and Energetic Effects: From the traditional yogic viewpoint, the Surya Namaskar activates Manipura Chakra, located near the solar plexus. This chakra has several functions, including metabolism, digestion, and the transformation of energy. The activation of this energy center enhances agni, or digestive fire, which contributes to improved metabolic function and lipid regulation.

During the sequence, synchronized breathing balances Ida and Pingala Nadis, harmonizing parasympathetic and sympathetic pathways, promoting homeostasis, enhancing the flow of prana throughout the body. The combination of movement and breath thus creates an integrated psychophysiological effect.

Limitations

This study has several limitations that must be considered when interpreting the findings. The sample size of 40 participants was relatively small, limiting the generalizability of the results. The intervention duration of 30 days may not have been long enough to capture sustained metabolic adaptations. Dietary habits were not monitored or standardized, allowing nutritional variations that could influence lipid and anthropometric outcomes. Psychological improvements reported by participants were not measured using validated tools, reducing the objectivity of these findings. Additionally, participants were not categorized based on menopausal or perimenopausal status, despite hormonal fluctuations significantly affecting metabolism, lipid levels, and body composition. Only basic lipid markers were included, restricting biochemical insights. Finally, subjective reporting was used to assess wellbeing and sleep quality, and no objective tools such as HRV monitoring, bioimpedance devices, or wearable trackers were employed.

Recommendations

Future research should address these limitations by increasing sample size and participant diversity to enhance external validity. Longer intervention periods of 60-90 days or more are recommended to evaluate sustained physiological changes. Incorporating structured dietary monitoring—such as food diaries, nutritional assessments, or standardized meal plans—would minimize dietary confounding. Psychological

outcomes should be assessed using validated instruments including the PSS, BAI, BDI, PSQI, and WHOQOL-BREF. Hormonal profiling and subgroup analysis based on menopausal and reproductive status would provide a clearer understanding of metabolic responses. Expanding biochemical investigations to include HDL, HbA1c, thyroid profile, cortisol, HOMA-IR, CRP, and IL-6 will offer comprehensive metabolic insight. Future studies should also adopt objective measurement tools such as HRV monitors, fitness trackers, and bioimpedance analysis to enhance accuracy. These improvements will strengthen methodological rigor and provide a deeper understanding of the effects of Surya Namaskar on metabolic health and wellbeing.

Conclusion

The present study has established that the Bihar Model Surya Namaskar intervention for 30 days is effective to bring about significant improvements in lipid metabolism and body composition for middle-aged women. There were meaningful reductions in total cholesterol, triglycerides, LDL, VLDL, body weight, BMI, waist circumference, and hip circumference following the intervention, while no positive changes were recorded in the control group. The findings clearly establish Surya Namaskar as an effective, holistic, non-pharmacological modality in improving metabolic health. The physiological improvements could be due to increased cardiovascular engagement, muscular activation, autonomic balance, and metabolic efficiency. At the biochemical level, yogic practice seems to affect the lipid profile by stimulating triglyceride breakdown, enhancing the process of reverse cholesterol transport, reducing hepatic synthesis of lipids, and increasing fatty acid oxidation. The psychological relaxation brought about by yogic breathing and Savasana might support a reduction in stress-mediated metabolic perturbances. This thus places Surya Namaskar as a non-invasive, easily accessible, and sustainable health-promoting activity for women within the age group of 37-52 years. It is a realistic method of managing dyslipidemia and central obesity and stress-related metabolic risk factors without pharmacological intervention. With further research involving longer intervention periods, hormonal profiling, nutritional control, and psychological assessment tools, Surya Namaskar could be positioned as a strong integrative therapy in lifestyle and preventive healthcare. These findings support SN as a holistic, drug-free strategy that could improve metabolic health and maintain physical fitness in women of reproductive age. Acknowledgment For this reason, the researcher would like to extend her heartfelt gratefulness to all research participants for their contribution and coordination.

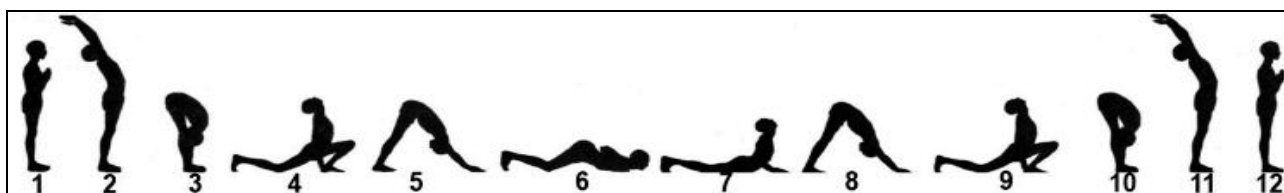
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Appendix A



Representation of Suryanamaskaar postures (Bihar model of yoga school). Picture was obtained and modified from the (23) book *Asana Pranayama Mudra Bandha* by Swami Satyananda Saraswathi